1318

Volume 3

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Series A

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- Motorola Non-Registered Type Numbers

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SERIES A
VOLUME III

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Series A

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VOLUME III

This volume contains complete data sheets for Motorola non-registered devices. Data sheets are in alphanumeric sequence according to device type number except for those data sheets that cover several devices with different type numbers. The alphanumerical index in front of the book permits the user to quickly locate the page number of the data sheet for any device characterized in the book.

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ALPHA-NUMERIC INDEX

Devices characterized in Volume III show the page reference only. Devices characterized in Volume I and Volume II are referenced by volume and page number.

DEVICE	VOL	PAGE
¼M2.4AZ		2
¼M2.7AZ		
¼M3.0AZ		
¼M3.3AZ		
¼M3.6AZ		
¼M3.9AZ		
¼M4.3AZ		
¼M4.7AZ		
¼M5.1AZ		
¼M5.6AZ		
¼M6.2AZ		
¼M6.8Z		
¼M7.5Z		
¼M8.2Z		
¼M9.1Z		
¼M10Z		
¼M11Z		
¼M12Z		
¼M13Z		
¼M14Z		
¼M15Z		
¼M16Z		
¼M17Z		
¼M18Z		
¼M19Z		
¼M20Z		
¼M22Z		
¼M24Z		
¼M25Z		
¼M27Z		
¼M30Z		
¼M33Z		
¼M36Z		
¼M39Z		
¼M43Z		
¼M45Z		
¼M47Z		
¼M50Z		
¼M52Z		
¼M56Z		
¼M62Z		
¼M68Z		
¼M75Z		
¼M82Z		
¼M91Z		
¼M100Z		
¼M105Z		
¼M110Z		
¼M120Z		
¼M130Z		
¼M140Z		
¼M150Z		
¼M175Z		
¼M200Z		2
.4M.64FR10	I	1-10
.4M1.36FR5		
.4M1.36FR2		
.4M2.04FR5		
.4M2.04FR2	I	1-10
.5M2.4ZS	II	1-20

DEVICE	VOL	PAGE
.5M2.5ZS	II	1-20
.5M2.7ZS		
.5M3.0ZS		
.5M3.3ZS		
.5M3.6ZS		
.5M3.9ZS		
.5M4.3ZS		
.5M4.7ZS		
.5M5.1ZS		
.5M5.6ZS		
.5M6.0ZS		
.5M6.2ZS		
.5M6.8ZS		
.5M7.5ZS		
.5M8.2ZS		
.5M8.7ZS		
.5M9.1ZS		
.5M10ZS		
.5M11ZS		
.5M12ZS		
.5M13ZS		
.5M14ZS		
.5M15ZS		
.5M16ZS		
.5M17ZS		
.5M18ZS		
.5M19ZS		
.5M20ZS		
.5M22ZS		
.5M24ZS		
.5M25ZS		
.5M27ZS		
.5M28ZS		
.5M30ZS		
.5M33ZS		
.5M36ZS		
.5M39ZS		
.5M43ZS		
.5M47ZS		
.5M51ZS		
.5M56ZS		
.5M60ZS		
.5M62ZS		
.5M68ZS		
.5M75ZS		
.5M82ZS		
.5M87ZS		
.5M91ZS		
.5M100ZS		
.5M110ZS		
.5M120ZS		
.5M130ZS		
.5M140ZS		
.5M150ZS		
.5M160ZS		
.5M170ZS		
.5M180ZS		
.5M190ZS		
.5M200ZS	II	1-20
1M3.3AZ10	I	1-59

DEVICE	VOL	PAGE
1M3.6AZ10	I	1-59
1M3.9AZ10		
1M4.3AZ10		
1M4.7AZ10		
1M5.1AZ10		
1M5.6AZ10		
1M6.2AZ10		
1M6.8AZ10		
1M7.5AZ10		
1M6.8Z		
1M7.5Z		
1M8.2Z		
1M9.1Z		
1M10Z		
1M11Z		
1M12Z		
1M13Z		
1M15Z		
1M16Z		
1M18Z		
1M20Z		
1M22Z		
1M24Z		
1M27Z		
1M30Z		
1M33Z		
1M36Z		
1M39Z		
1M43Z		
1M47Z		
1M51Z		
1M56Z		
1M62Z		
1M68Z		
1M75Z		
1M82Z		
1M91Z		
1M100Z		
1M110Z		
1M120Z		
1M130Z		
1M150Z		
1M160Z		
1M180Z		
1M200Z		1-59
1M3.3ZS10		1-100
1M3.6ZS10		
1M3.9ZS10		
1M4.3ZS10		
1M4.7ZS10		
1M5.1ZS10		
1M5.6ZS10		
1M6.2ZS10		
1M6.8ZS10		
1M7.5ZS10		
1M8.2ZS10		
1M9.1ZS10		
1M10ZS10		
1M11ZS10		
1M12ZS10	I	1-100

DEVICE	VOL	PAGE
1M13ZS10	I	1-100
1M15ZS10		
1M16ZS10		
1M18ZS10		
1M20ZS10		
1M22ZS10		
1M24ZS10		
1M27ZS10		
1M30ZS10		
1M33ZS10		
1M36ZS10		
1M39ZS10		
1M43ZS10		
1M47ZS10		
1M51ZS10		
1M56ZS10		
1M62ZS10		
1M68ZS10		
1M75ZS10		
1M82ZS10		
1M91ZS10		
1M100ZS10		
1M110ZS10		
1M120ZS10		
1M130ZS10		
1M150ZS10		
1M160ZS10		
1M180ZS10		
1M200ZS10	I	1-100
5M3.3ZS	II	1-30
5M3.6ZS		
5M3.9ZS		
5M4.3ZS		
5M4.7ZS		
5M5.1ZS		
5M5.6ZS		
5M6.0ZS		
5M6.2ZS		
5M6.8ZS		
5M7.5ZS		
5M8.2ZS		
5M8.7ZS		
5M9.1ZS		
5M10ZS		
5M11ZS		
5M12ZS		
5M13ZS		
5M14ZS		
5M15ZS		
5M16ZS		
5M17ZS		
5M18ZS		
5M19ZS		
5M20ZS		
5M22ZS		
5M24ZS		
5M25ZS		
5M27ZS		
5M28ZS		
5M30ZS		
5M33ZS		
5M36ZS		
5M39ZS		
5M43ZS		
5M47ZS		
5M51ZS		
5M56ZS		
5M60ZS		
5M62ZS		
5M68ZS	II	1-30
5M75ZS	II	1-30
5M82ZS		
5M87ZS		
5M91ZS		
5M100ZS		
5M110ZS		
5M120ZS		
5M130ZS		
5M140ZS		
5M150ZS		
5M160ZS		
5M170ZS		
5M180ZS		
5M190ZS		
5M200ZS	II	1-30
10M6.8Z		1-44
10M7.5Z		
10M8.2Z		
10M9.1Z		
10M10Z		
10M11Z		
10M12Z		
10M13Z		
10M14Z		
10M15Z		
10M16Z		
10M18Z		
10M19Z		
10M20Z		
10M22Z		
10M24Z		
10M27Z		
10M30Z		
10M33Z		
10M36Z		
10M39Z		
10M43Z		
10M47Z		
10M50Z		
10M51Z		
10M52Z		
10M56Z		
10M62Z		
10M68Z		
10M75Z		
10M82Z		
10M91Z		
10M100Z		
10M105Z		
10M110Z		
10M120Z		
10M130Z		
10M140Z		
10M150Z		
10M160Z		
10M180Z		
10M200Z		1-44
50M3.9Z		1-41
50M4.3Z		
50M4.7Z		
50M5.1Z		
50M5.6Z		
50M6.2Z		
50M6.8Z		
50M7.5Z		
50M8.2Z		
50M9.1Z		
50M10Z		
50M11Z		
50M12Z	I	1-41
50M13Z	I	1-41
50M14Z		
50M15Z		
50M16Z		
50M17Z		
50M18Z		
50M19Z		
50M20Z		
50M22Z		
50M24Z		
50M25Z		
50M27Z		
50M30Z		
50M33Z		
50M36Z		
50M39Z		
50M43Z		
50M45Z		
50M47Z		
50M50Z		
50M51Z		
50M52Z		
50M56Z		
50M62Z		
50M68Z		
50M75Z		
50M82Z		
50M91Z		
50M100Z		
50M105Z		
50M110Z		
50M120Z		
50M130Z		
50M140Z		
50M150Z		
50M160Z		
50M175Z		
50M180Z		
50M200Z	I	1-41
BB105A,B,G		4
BU105		364
BU108		6
MA202		12
MA206		12
MA4404		14
MA4404A		14
MAC5-1		16
MAC5-2		
MAC5-3		
MAC5-4		
MAC5-5		
MAC5-6		
MAC5-7		
MAC5-8		
MAC6-1		
MAC6-2		
MAC6-3		
MAC6-4		
MAC6-5		
MAC6-6		
MAC6-7		
MAC6-8		16
MAC10-1		20
MAC10-2		
MAC10-3		
MAC10-4		
MAC10-5		
MAC10-6		
MAC10-7		
MAC10-8		20

DEVICE	VOL	PAGE
MAC11-1		20
MAC11-2		
MAC11-3		
MAC11-4		
MAC11-5		
MAC11-6		
MAC11-7		↓
MAC11-8		20
MAC37-1		24
MAC37-2		
MAC37-3		
MAC37-4		
MAC37-5		
MAC37-6		
MAC37-7		
MAC38-1		
MAC38-2		
MAC38-3		
MAC38-4		
MAC38-5		
MAC38-6		↓
MAC38-7		24
MAC92,A-1		28
MAC92,A-2		
MAC92,A-3		
MAC92,A-4		
MAC92,A-5		↓
MAC92,A-6		28
MAC93,A-1		32
MAC93,A-2		
MAC93,A-3		↓
MAC93,A-4		32
MAC94,A-1		36
MAC94,A-2		
MAC94,A-3		↓
MAC94,A-4		36
MAC40688	II	2-164
MAC40689	II	2-164
MAC40690	II	2-164
MAC40797	II	2-186
MAC40798	II	2-186
MAC800-02,A,B		40
MAC800-05,A,B		
MAC800-10,A,B		
MAC800-20,A,B		
MAC800-40,A,B		
MAC800-60,A,B		↓
MAC800-80,A,B		40
MBD101		44
MBD102		46
MBD103		48
MBD501		50
MBD502		52
MBD701		50
MBD702		52
MBI-101		54
MBR320M		56
MBR330M		56
MBR340M		56
MBR1520		60
MBR1530		60
MBR1540		60
MBR2520		64
MBR2530		64
MBR2540		64
MBR4020		68
MBR4020PF		72
MBR4030		68
MBR4030PF		72
MBR4040		68
MBS100		76
MBS4991		78
MBS4992		78
MCA1911N,P		82
MCA1912N,P		
MCA1913N,P		
MCA1914N,P		
MCA1921N,P		
MCA1922N,P		
MCA1923N,P		
MCA1924N,P		
MCA1931N,P		
MCA1932N,P		
MCA1933N,P		
MCA1934N,P		
MCA2011N,P		
MCA2012N,P		
MCA2013N,P		
MCA2014N,P		
MCA2021N,P		
MCA2022N,P		
MCA2023N,P		
MCA2024N,P		
MCA2031N,P		
MCA2032N,P		
MCA2033N,P		
MCA2034N,P		
MCA2111N,P		
MCA2112N,P		
MCA2113N,P		
MCA2114N,P		
MCA2121N,P		
MCA2122N,P		
MCA2123N,P		
MCA2124N,P		
MCA2131N,P		
MCA2132N,P		
MCA2133N,P		
MCA2134N,P		
MCA2211N,P		
MCA2212N,P		
MCA2213N,P		
MCA2214N,P		
MCA2221N,P		
MCA2222N,P		
MCA2223N,P		
MCA2224N,P		
MCA2231N,P		
MCA2232N,P		
MCA2233N,P		↓
MCA2234N,P		82
MCL1300		84
MCL1301		
MCL1302		
MCL1303		↓
MCL1304		84
MCLTC6010		85
MCLTC6025		
MCLTC6050		↓
MCLTC6100		85
MCR32-05		87
MCR32-20		
MCR32-30		
MCR32-40		
MCR32-50		↓
MCR32-60		87
MCR39-05		91
MCR39-20		91
MCR39-30		91
MCR39-40		91
MCR39-50		91
MCR39-60		91
MCR051		93
MCR052		
MCR053		↓
MCR054		93
MCR80-0.5		97
MCR80-10		
MCR80-20		
MCR80-30		
MCR80-40		
MCR80-50		
MCR80-60		
MCR80-70		
MCR80-80		
MCR81-0.5		
MCR81-10		
MCR81-20		
MCR81-30		
MCR81-40		
MCR81-50		
MCR81-60		
MCR81-70		
MCR81-80		
MCR82-0.5		
MCR82-10		
MCR82-20		
MCR82-30		
MCR82-40		
MCR82-50		
MCR82-60		
MCR82-70		↓
MCR82-80		97
MCR101		99
MCR102		
MCR103		↓
MCR104		99
MCR106-1		101
MCR106-2		
MCR106-3		
MCR106-4		
MCR106-6		↓
MCR106-8		101
MCR107-1		103
MCR107-2		
MCR107-3		
MCR107-4		
MCR107-5		
MCR107-6		
MCR107-7		↓
MCR107-8		103
MCR115		105
MCR120		105
MCR154-10		107
MCR154-20		
MCR154-30		
MCR154-40		
MCR154-50		
MCR154-60		
MCR155-10		
MCR155-20		
MCR155-30		
MCR155-40		
MCR155-50		
MCR155-60		
MCR156-10		
MCR156-20		
MCR156-30		↓
MCR156-40		107

DEVICE	VOL	PAGE	DEVICE	VOL	PAGE	DEVICE	VOL	PAGE
MCR156-50		107	MCR320-2		125	MCR470-110		141
MCR156-60			MCR320-3			MCR470-120		
MCR157-10			MCR320-4			MCR470-130		
MCR157-20			MCR320-5			MCR470-140		
MCR157-30			MCR320-6			MCR470-150		141
MCR157-40			MCR320-7			MCR470C-10		145
MCR157-50			MCR320-8		125	MCR470C-20		
MCR157-60		107	MCR380-10		129	MCR470C-30		
MCR158-50		111	MCR380-20			MCR470C-40		
MCR158-60			MCR380-30			MCR470C-50		
MCR158-70			MCR380-40			MCR470C-60		
MCR158-80			MCR380-50			MCR470C-70		
MCR158-90			MCR380-60			MCR470C-80		
MCR158-100			MCR380-70			MCR470D-10		
MCR158-110			MCR380-80			MCR470D-20		
MCR158-120			MCR380-90			MCR470D-30		
MCR159-50			MCR380-100			MCR470D-40		
MCR159-60			MCR380-110			MCR470D-50		
MCR159-70			MCR380-120			MCR470D-60		
MCR159-80			MCR380-130			MCR470D-70		
MCR159-90			MCR380-140			MCR470D-80		
MCR159-100			MCR380-150		129	MCR470D-90		
MCR159-110			MCR380B-10		133	MCR470D-100		
MCR159-120		111	MCR380B-20			MCR470E-10		
MCR201		115	MCR380B-30			MCR470E-20		
MCR202			MCR380B-40			MCR470E-30		
MCR203			MCR380B-50			MCR470E-40		
MCR204			MCR380B-60			MCR470E-50		
MCR205			MCR380B-70			MCR470E-60		
MCR206		115	MCR380B-80			MCR470E-70		
MCR235-10		119	MCR380C-10			MCR470E-80		
MCR235-20			MCR380C-20			MCR470E-90		
MCR235-30			MCR380C-30			MCR470E-100		
MCR235-40			MCR380C-40			MCR470E-120		145
MCR235-50			MCR380C-50			MCR550C-10		147
MCR235-60			MCR380C-60			MCR550C-20		
MCR235-70			MCR380C-70			MCR550C-30		
MCR235-80			MCR380C-80			MCR550C-40		
MCR235-90			MCR380C-90			MCR550C-50		
MCR235-100			MCR380C-100			MCR550C-60		
MCR235-110			MCR380D-10			MCR550C-70		
MCR235-120			MCD380D-20			MCR550C-80		
MCR235-130			MCR380D-30			MCR550C-90		
MCR235-140			MCR380D-40			MCR550C-100		
MCR235-150		119	MCR380D-50			MCR550D-10		
MCR235A-10		123	MCR380D-60			MCR550D-20		
MCR235A-20			MCR380D-70			MCR550D-30		
MCR235A-30			MCR380D-80			MCR550D-40		
MCR235A-40			MCR380D-90			MCR550D-50		
MCR235A-50			MCR380D-100			MCR550D-60		
MCR235A-60			MCR380D-110			MCR550D-70		
MCR235B-10			MCR380D-120		133	MCR550D-80		
MCR235B-20			MCR406-1		135	MCR550D-90		
MCR235B-30			MCR406-2			MCR550D-100		
MCR235B-40			MCR406-3			MCR550D-110		
MCR235B-50			MCR406-4		135	MCR550D-120		147
MCR235B-60			MCR407-1		139	MCR649-1		149
MCR235B-70			MCR407-2			MCR649-2		
MCR235B-80			MCR407-3			MCR649-3		
MCR235C-10			MCR407-4		139	MCR649-4		
MCR235C-20			MCR470-10		141	MCR649-5		
MCR235C-30			MCR470-20			MCR649-6		
MCR235C-40			MCR470-30			MCR649-7		149
MCR235C-50			MCR470-40			MCR729-5		152
MCR235C-60			MCR470-50			MCR729-6		
MCR235C-70			MCR470-60			MCR729-7		
MCR235C-80			MCR470-70			MCR729-8		
MCR235C-90			MCR470-80			MCR729-9		
MCR235C-100		123	MCR470-90			MCR729-10		152
MCR320-1		125	MCR470-100		141	MCR800-10		154

DEVICE	VOL	PAGE
MCR800-20		154
MCR800-30		
MCR800-40		
MCR800-50		
MCR800-60		
MCR800-70		
MCR800-80		
MCR800-90		
MCR800-100		
MCR800-110		
MCR800-120		
MCR800-130		
MCR800-140		
MCR800-150		154
MCR846-1		158
MCR846-2		
MCR846-3		
MCR846-4		158
MCR1336-5		160
MCR1336-6		
MCR1336-7		
MCR1336-8		
MCR1336-9		
MCR1336-10		160
MCR1718-5		162
MCR1718-6		
MCR1718-7		
MCR1718-8		162
MCR1906-1		164
MCR1906-2		
MCR1906-3		
MCR1906-4		164
MCR1907-1		166
MCR1907-2		
MCR1907-3		
MCR1907-4		
MCR1907-5		
MCR1907-6		166
MCR2315-1		169
MCR2315-2		
MCR2315-3		
MCR2315-4		
MCR2315-5		
MCR2315-6		
MCR2614L-1		
MCR2614L-2		
MCR2614L-3		
MCR2614L-4		
MCR2614L-5		
MCR2614L-6		169
MCR3818-1		171
MCR3818-2		
MCR3818-3		
MCR3818-4		
MCR3818-5		
MCR3818-6		
MCR3818-7		
MCR3818-8		171
MCR3835-1		173
MCR3835-2		
MCR3835-3		
MCR3835-4		
MCR3835-5		
MCR3835-6		
MCR3835-7		
MCR3835-8		173
MCR3918-1		171
MCR3918-2		171
MCR3918-3		171

DEVICE	VOL	PAGE
MCR3918-4		171
MCR3918-5		
MCR3918-6		
MCR3918-7		
MCR3918-8		171
MCR3935-1		173
MCR3935-2		
MCR3935-3		
MCR3935-4		
MCR3935-5		
MCR3935-6		
MCR3935-7		
MCR3935-8		173
MD708,A,B		175
MD708F,AF,BF		175
MD918,A,B		178
MD918F,AF,BF		178
MD982,F		181
MD984		183
MD985,F		185
MD986,F		187
MD1120,F		189
MD1121		189
MD1122		189
MD1123		191
MD1129,F		193
MD1130,F		191
MD2218,A,F,AF		195
MD2219,A,F,AF		195
MD2369,A,B,F,AF,BF		200
MD2904,A,F,AF		204
MD2905,A,F,AF		204
MD3250,A,F,AF		209
MD3251,A,F,AF		209
MD3409		213
MD3410		213
MD3467,F		215
MD3725,F		219
MD3762,F		223
MD4957		227
MD5000,A,B		231
MD6001,F		233
MD6002,F		233
MD6003,F		233
MD7000		238
MD7001,F		240
MD7002,A,B		242
MD7003,F		244
MD7003A,AF		244
MD7003B		244
MD7004,F		246
MD7007,A,B		248
MD7007F		248
MD7021,F		250
MD8001		252
MD8002		252
MD8003		252
MDA100		254
MDA101		
MDA102		
MDA104		
MDA106		
MDA108		
MDA110		254
MDA800		256
MDA801		
MDA802		
MDA804		
MDA806		256
MDA920		260

DEVICE	VOL	PAGE
MDA922-1		262
MDA922-2		
MDA922-3		
MDA922-4		
MDA922-5		
MDA922-6		
MDA922-7		
MDA922-8		
MDA922-9		262
MDA942-1		266
MDA942-2		
MDA942-3		
MDA942-4		
MDA942-5		
MDA942-6		266
MDA952FR-1		270
MDA952FR-2		
MDA952FR-3		
MDA952FR-4		
MDA952FR-5		270
MDA970-1		271
MDA970-2		271
MDA970-3		271
MDA972-1		266
MDA972-2		
MDA972-3		
MDA972-4		
MDA972-5		266
MDA980-1		275
MDA980-2		
MDA980-3		
MDA980-4		
MDA980-5		
MDA980-6		
MDA990-1		
MDA990-2		
MDA990-3		
MDA990-4		
MDA990-5		
MDA990-6		275
MDA1200		279
MDA1201		
MDA1202		
MDA1204		
MDA1206		279
MDA1330H		283
MDA1331H		
MDA1332H		
MDA1333H		283
MDA1505-1		266
MDA1505-2		
MDA1505-3		
MDA1505-4		
MDA1505-5		
MDA1505-6		
MDA1591-1		
MDA1591-2		
MDA1591-3		
MDA1591-4		
MDA1591-5		
MDA1591-6		266
MDA3551		287
MDA3552		
MDA3661		
MDA3662		287
MFE130		796
MFE131		796
MFE132		796
MFE590		289
MFE591		289

DEVICE	VOL	PAGE	DEVICE	VOL	PAGE	DEVICE	VOL	PAGE
MFE823		295	MJ450		378	MJ4646		456
MFE824		297	MJ480		380	MJ4647		456
MFE2000		299	MJ481		380	MJ4648		456
MFE2001		299	MJ490		382	MJ5415	I	2-499
MFE2004		301	MJ491		382	MJ5416	I	2-499
MFE2005		301	MJ802		384	MJ6257		437
MFE2006		301	MJ900		386	MJ6302		442
MFE2007		303	MJ901		386	MJ6700		458
MFE2008		303	MJ920		388	MJ6701		458
MFE2009		303	MJ921		388	MJ7000		460
MFE2010		305	MJ1000		386	MJ7160		462
MFE2011		305	MJ1001		386	MJ7161		462
MFE2012		305	MJ1200		388	MJ7260		466
MFE2093		307	MJ1201		388	MJ7261		466
MFE2094		307	MJ1800		393	MJ8100		468
MFE2095		307	MJ2249		395	MJ8101		468
MFE3001		308	MJ2250		395	MJ9000		470
MFE3002		310	MJ2251		397	MJE105		472
MFE3003		311	MJ2252		397	MJE105K		472
MFE3004		312	MJ2253		399	MJE170		475
MFE3005		312	MJ2254		399	MJE171		↓
MFE3006		314	MJ2267		401	MJE172		↓
MFE3007		314	MJ2268		401	MJE180		↓
MFE3008		314	MJ2500		403	MJE181		↓
MFE3020		320	MJ2501		403	MJE182		475
MFE3021		320	MJ2801		405	MJE200		479
MFE4007		322	MJ2840		407	MJE205		483
MFE4008		↓	MJ2841		407	MJE205K		483
MFE4009		↓	MJ2901		405	MJE210		479
MFE4010		↓	MJ2940		409	MJE220		486
MFE4011		↓	MJ2941		409	MJE221		↓
MFE4012		322	MJ2955		411	MJE222		↓
MFE5000		328	MJ3000		403	MJE223		↓
MHQ918		330	MJ3001		403	MJE224		↓
MHQ2221		332	MJ3026		415	MJE225		↓
MHQ2222		332	MJ3027		415	MJE230		↓
MHQ2369		334	MJ3028		417	MJE231		↓
MHQ2483		336	MJ3029		419	MJE232		↓
MHQ2484		336	MJ3030		419	MJE233		↓
MHQ2906		338	MJ3040		421	MJE234		↓
MHQ2907		338	MJ3041		421	MJE235		486
MHQ3467		340	MJ3042		421	MJE240		490
MHQ3546		342	MJ3101		395	MJE241		↓
MHQ3798		344	MJ3201		423	MJE242		↓
MHQ3799		344	MJ3202		423	MJE243		↓
MHQ4001A		346	MJ3260		425	MJE244		↓
MHQ4002A		346	MJ3430		429	MJE250		↓
MHQ4013		348	MJ3480		6	MJE251		↓
MHQ4014		348	MJ3583	I	2-537	MJE252		↓
MHQ6001		350	MJ3584	I	2-537	MJE253		↓
MHQ6002		350	MJ3585	I	2-537	MJE254		490
MHQ6100		352	MJ3701		399	MJE340		494
MHQ6100A		352	MJ3760		431	MJE340K		494
MHW559		354	MJ3761		431	MJE341		497
MHW560		355	MJ3771		437	MJE341K		↓
MHW561		356	MJ3772		437	MJE344		↓
MHW562		357	MJ3773		442	MJE344K		497
MHW709		358	MJ4030		447	MJE350		500
MHW710		361	MJ4031		↓	MJE370		502
MJ105		364	MJ4032		↓	MJE370K		502
MJ400		368	MJ4033		↓	MJE371		505
MJ410		370	MJ4034		↓	MJE371K		505
MJ411		370	MJ4035		447	MJE520		508
MJ413		372	MJ4200		449	MJE520K		508
MJ420S		374	MJ4201		↓	MJE521		511
MJ421S		374	MJ4210		↓	MJE521K		511
MJ423		372	MJ4211		449	MJE700		514
MJ424		376	MJ4240		2-537	MJE701		↓
MJ425		376	MJ4502		454	MJE702		↓
MJ431		372	MJ4645		456	MJE703		514
						MJE710		516

DEVICE	VOL	PAGE	DEVICE	VOL	PAGE	DEVICE	VOL	PAGE
MJE711		516	MJE5192	II	2-67	MM3007		607
MJE712		516	MJE5193		2-71	MM3008		609
MJE720		518	MJE5194		2-71	MM3009		609
MJE721		518	MJE5195		2-71	MM3053		611
MJE722		518	MJE5655		2-237	MM3726		613
MJE800		514	MJE5656		2-237	MM3734		617
MJE801			MJE5657		2-237	MM3735		617
MJE802			MJE5974		2-374	MM3736		621
MJE803		514	MJE5975		2-374	MM3737		621
MJE1090		520	MJE5976		2-374	MM3903		625
MJE1091			MJE5977		2-378	MM3904		625
MJE1092			MJE5978		2-378	MM3905		630
MJE1093			MJE5979		2-378	MM3906		630
MJE1100			MJE5980		2-382	MM4000		635
MJE1101			MJE5981		2-382	MM4001		
MJE1102			MJE5982		2-382	MM4002		
MJE1103		520	MJE5983		2-386	MM4003		635
MJE1290		523	MJE5984		2-386	MM4005		636
MJE1291			MJE5985		2-386	MM4006		636
MJE1660			MJE6040		2-408	MM4007		636
MJE1661		523	MJE6041			MM4008		638
MJE2010		525	MJE6042			MM4009		638
MJE2011			MJE6043			MM4010		638
MJE2020			MJE6044			MM4018		640
MJE2021		525	MJE6045	II	2-408	MM4019		642
MJE2050		527	MLED50		557	MM4030		646
MJE2090		520	MLED55		557	MM4031		
MJE2091			MLED60		559	MM4032		
MJE2092			MLED90		559	MM4033		646
MJE2093			MLED92		561	MM4036		648
MJE2100			MLED440		563	MM4037		650
MJE2101			MLED445		565	MM4049		652
MJE2102			MLED500		567	MM4052		654
MJE2103		520	MLED600		569	MM4208		656
MJE2150		527	MLED610		571	MM4208A		
MJE2160		528	MLED640		573	MM4209		
MJE2360		530	MLED655		575	MM4209A		656
MJE2361		530	MLED660		577	MM4257		658
MJE2370		532	MLED900		579	MM4258		658
MJE2480		534	MLED910		581	MM4261H		662
MJE2481			MLED930		583	MM5005		670
MJE2482			MLS101		585	MM5006		670
MJE2483		534	MLS102			MM5007		670
MJE2490		536	MLS103			MM5189		672
MJE2491		536	MLS104			MM5262		674
MJE2520		538	MLS105			MM6427		676
MJE2801		540	MLS201			MM8000		678
MJE2801K		540	MLS202			MM8001		678
MJE2901		543	MLS203			MM8006		680
MJE2901K		543	MLS204			MM8007		680
MJE2955		546	MLS205		585	MM8008		684
MJE2955K		546	MM439		587	MM8009		688
MJE3055		549	MM1500,A		589	MM8010		684
MJE3055K		549	MM1501		589	MM8011		684
MJE3370		502	MM1505		591	MMCM918		691
MJE3371		505	MM1553		593	MMCM930		693
MJE3439		552	MM1748,A		597	MMCM2222		695
MJE3440		552	MM1803	I	2-425	MMCM2369		697
MJE3520		508	MM1941		599	MMCM2484		693
MJE3521		511	MM2005-2		601	MMCM2857		729
MJE3738		554	MM2258		603	MMCM2907		699
MJE3739		554	MM2259		603	MMCM3798		738
MJE4918	I	2-872	MM2260		603	MMCM3799		738
MJE4919	I	2-872	MM3000		606	MMCM3903		743
MJE4920	I	2-872	MM3001			MMCM3904		743
MJE4921	I	2-876	MM3002			MMCM3905		747
MJE4922	I	2-876	MM3003		606	MMCM3906		747
MJE4923	I	2-876	MM3005		607	MMCM3960A		753
MJE5190	II	2-67	MM3006		607	MMD70		701
MJE5191	II	2-67				MMD6050		702

DEVICE	VOL	PAGE
MMD6100		702
MMD6150		702
MMD7000		702
MMD7001		704
MMF1		706
MMF2		↓
MMF3		↓
MMF4		↓
MMF5		↓
MMF6		706
MMT70		708
MMT71		709
MMT72		710
MMT73		712
MMT74		714
MMT75		716
MMT76		716
MMT806		718
MMT807		720
MMT808		722
MMT809		724
MMT918		691
MMT930		693
MMT2222		726
MMT2369		697
MMT2484		693
MMT2857		729
MMT2907		731
MMT3014		734
MMT3546		736
MMT3798		738
MMT3799		738
MMT3823		741
MMT3903		743
MMT3904		743
MMT3905		747
MMT3906		747
MMT3960		751
MMT3960A		753
MMT8015		756
MOC2000		761
MP110		763
MP110B		765
MP500		767
MP501		↓
MP502		↓
MP504		↓
MP505		↓
MP506		767
MP600		769
MP601		↓
MP602		↓
MP603		↓
MP1613		771
MP2000A		773
MP2060		777
MP2061		↓
MP2062		↓
MP2063		777
MP2100A		773
MP2200A		↓
MP2300A		↓
MP2400A		773
MP3730		781
MP3731		781
MPC1000		783
MPF102		789
MPF108		790
MPF109		792
MPF111		794

DEVICE	VOL	PAGE
MPF112		795
MPF130		796
MPF131		796
MPF132		796
MPF161		800
MPF256		802
MPF820		803
MPF970		805
MPF971		805
MPF4391		809
MPF4392		809
MPF4393		809
MPI-3401		813
MPM5006		815
MPN3401		817
MPN3402		817
MPN3411		819
MPN3601		821
MPQ918		823
MPQ1000		825
MPQ1050		827
MPQ2221		332
MPQ2222		332
MPQ2369		334
MPQ2483		829
MPQ2484		829
MPQ2906		338
MPQ2907		338
MPQ3303		831
MPQ3467		833
MPQ3546		342
MPQ3725,A		835
MPQ3762		838
MPQ3798		840
MPQ3799		840
MPQ3904		842
MPQ3906		844
MPQ4003		846
MPQ4004		846
MPQ6001		849
MPQ6002		849
MPQ6100		851
MPQ6100A		851
MPQ6501		849
MPQ6502		849
MPQ6600,A		851
MPQ6700		853
MPS404		855
MPS404A		855
MPS706,A		859
MPS708		861
MPS753		863
MPS834		865
MPS835		867
MPS918		869
MPS2369		871
MPS2712		873
MPS2714		875
MPS2716		873
MPS2923		877
MPS2924		877
MPS2925		877
MPS2926		879
MPS3390		881
MPS3391		↓
MPS3392		↓
MPS3393		↓
MPS3394		↓
MPS3395		↓
MPS3396		881

DEVICE	VOL	PAGE
MPS3397		881
MPS3398		881
MPS3563		869
MPS3638,A		883
MPS3639		885
MPS3640		887
MPS3646		890
MPS3693		894
MPS3694		894
MPS3702		896
MPS3703		896
MPS3704		898
MPS3705		898
MPS3706		898
MPS3707		900
MPS3709		↓
MPS3710		↓
MPS3711		900
MPS3826		902
MPS3827		902
MPS4354		904
MPS4355		904
MPS4356		904
MPS5172		908
MPS6507		910
MPS6511		912
MPS6512		914
MPS6513		↓
MPS6514		↓
MPS6515		↓
MPS6516		↓
MPS6517		↓
MPS6518		↓
MPS6519		914
MPS6520		916
MPS6521		↓
MPS6522		↓
MPS6523		916
MPS6530		918
MPS6531		↓
MPS6532		↓
MPS6533		↓
MPS6534		↓
MPS6535		918
MPS6539		920
MPS6540		922
MPS6541		924
MPS6543		926
MPS6544		928
MPS6545		928
MPS6546		930
MPS6547		932
MPS6548		934
MPS6560		936
MPS6561		940
MPS6562		936
MPS6563		940
MPS6565		944
MPS6566		944
MPS6567		948
MPS6568,A		950
MPS6569,A		950
MPS6970,A		950
MPS6571		954
MPS6573		957
MPS6574		↓
MPS6575		↓
MPS6576		957
MPS6580		959
MPS8000		961

DEVICE	VOL	PAGE
MPS8001		963
MPS8907		965
MPS8098		970
MPS8099		↓
MPS8598		↓
MPS8599		970
MPS-A05		976
MPS-A06		976
MPS-A09		982
MPS-A12		985
MPS-A13		987
MPS-A14		987
MPS-A16		990
MPS-A17		990
MPS-A18		992
MPS-A20		997
MPS-A42		1001
MPS-A43		1001
MPS-A55		976
MPS-A56		976
MPS-A65		1003
MPS-A66		1003
MPS-A70		1006
MPS-A92		1010
MPS-A93		1010
MPS-D01		1012
MPS-D02		1014
MPS-D03		1016
MPS-D04		1018
MPS-D05		1020
MPS-D06		1022
MPS-D51		1012
MPS-D52		1014
MPS-D53		1016
MPS-D54		1018
MPS-D55		1020
MPS-D56		1022
MPS-H02		1025
MPS-H04		1028
MPS-H05		1028
MPS-H07		1032
MPS-H08		1032
MPS-H10		1036
MPS-H11		1036
MPS-H17		1039
MPS-H19		1041
MPS-H20		1043
MPS-H24		1046
MPS-H30		1049
MPS-H31		1049
MPS-H32		1053
MPS-H34		1057
MPS-H37		1060
MPS-H54		1062
MPS-H55		1062
MPS-H81		1066
MPS-H83		1068
MPS-H85		1072
MPS-K20		997
MPS-K21		997
MPS-K22		997
MPS-K70		1006
MPS-K71		1006
MPS-K72		1006
MPS-L01		1074
MPS-L51		1078
MPS-U01,A		1082
MPS-U02		1084
MPS-U03		1086
MPS-U04		1086
MPS-U05		1087
MPS-U06		1087
MPS-U07		1089
MPS-U10		1091
MPS-U31		1095
MPS-U45		1099
MPS-U51,A		1103
MPS-U52		1105
MPS-U55		1107
MPS-U56		1107
MPS-U57		1109
MPS-U60		1111
MPS-U95		1113
MPT20		1117
MPT28		1119
MPT32		1119
MPU131		1121
MPU132		1121
MPU133		1121
MPU6027		1125
MPU6028		1125
MPZ5-16		1129
MPZ5-32		1129
MPZ5-180		1129
MQ930		1131
MQ982		181
MQ1120		189
MQ1129		193
MQ2218,A		195
MQ2219,A		195
MQ2369		200
MQ2484		1131
MQ2904		204
MQ2905A		204
MQ3251		209
MQ3467		215
MQ3725		219
MQ3762		223
MQ3798		1134
MQ3799,A		1134
MQ6001		233
MQ6002		233
MQ7001		240
MQ7003		244
MQ7004		246
MQ7007		248
MQ7021		250
MR1-1200		1138
MR1-1400		1138
MR1-1600		1138
MR250-1		1141
MR250-2		↓
MR250-3		↓
MR250-4		↓
MR250-5		1141
MR327	I	1-50
MR328	↓	↓
MR330	↓	↓
MR331	I	1-50
MR501		1143
MR502		↓
MR504		↓
MR506		↓
MR508		↓
MR510		1143
MR751		1149
MR752		↓
MR754		↓
MR756		1149
MR810		1154
MR811		1154
MR812		↓
MR814		↓
MR816		↓
MR817		↓
MR818		1153
MR820		1159
MR821		↓
MR822		↓
MR824		↓
MR826		1159
MR830		1167
MR831		↓
MR832		↓
MR824		↓
MR836		↓
MR840		↓
MR841		↓
MR842		↓
MR844		↓
MR846		1167
MR850		1168
MR851		↓
MR852		↓
MR854		↓
MR856		1168
MR860		1176
MR861		↓
MR862		↓
MR864		↓
MR866		1176
MR870		1181
MR871		↓
MR872		↓
MR874		↓
MR876		1181
MR1030	I	1-98
MR1031	↓	↓
MR1032	↓	↓
MR1033	↓	↓
MR1034	↓	↓
MR1035	↓	↓
MR1036	↓	↓
MR1038	↓	↓
MR1040	I	1-98
MR1120		1187
MR1121		↓
MR1122		↓
MR1123		↓
MR1124		↓
MR1125		↓
MR1126		↓
MR1128		↓
MR1130		1187
MR1205FL		1191
MR1209FL		1191
MR1215FL		1194
MR1219FL		1194
MR1235FL,SL		1198
MR1239FL,SL		1198
MR1245FL,SL		1201
MR1249FL,SL		1201
MR1265FL		1203
MR1269FL		1203
MR1337-1		1205
MR1337-2		↓
MR1337-3		↓
MR1337-4		↓
MR1337-5		1205
MR1366	I	1-64

DEVICE	VOL	PAGE	DEVICE	VOL	PAGE	DEVICE	VOL	PAGE
MR1376	I	1-69	MRF226		1285	MV1632		1410
MR1386	I	1-74	MRF230		1287	MV1634		
MR1396	I	1-79	MRF231		1291	MV1636		
MR1815SL		1194	MRF232		1295	MV1638		
MR1819SL		1194	MRF233		1299	MV1640		
MR2000S		1208	MRF234		1303	MV1642		
MR2001S			MRF304		1307	MV1644		
MR2002S			MRF305		1311	MV1646		
MR2004S			MRF401		1315	MV1648		
MR2006S			MRF501		1318	MV1650		1410
MR2008S			MRF502		1318	MV1652		1411
MR2010S		1208	MRF509		1320	MV1654		
MR2083HA		1212	MRF511		1324	MV1656		
MR2266		1214	MRF603		1330	MV1658		
MR2271	I	1-107	MRF607		1332	MV1660		
MR2272		1216	MRF618		1335	MV1662		
MR2273		1214	MRF619		1339	MV1664		
MR2500		1218	MRF620		1339	MV1666		1411
MR2500S		1224	MRF621		1343	MV1803	I	2-425
MR2501		1218	MRF628		1347	MV1805C		1413
MR2501S		1224	MRF816		1350	MV1809C1		1415
MR2502		1218	MRF817		1353	MV1858D		1417
MR2502S		1224	MRF818		1357	MV1860D		
MR2504		1218	MRF5174		1361	MV1862D		
MR2504S		1224	MRF5175		1364	MV1863D		
MR2506		1218	MRF5176		1367	MV1864D		
MR2506S		1224	MRF5177		1370	MV1865D		1417
MR2508		1218	MRF8004		1374	MV1866		1421
MR2508S		1224	MSD6100		1376	MV1866D		1417
MR2510		1218	MSD6101		1378	MV1868		1421
MR2510S		1224	MSD6102		1380	MV1868D		1417
MR2525		1228	MSD6150		1382	MV1870		1421
MR2525R		1228	MSD7000		1384	MV1870D		1417
MR5005		1233	MU851		1386	MV1871		1421
MR5010			MU852		1386	MV1872		
MR5020			MU853		1386	MV1874		
MR5030			MU2646		1388	MV1876		
MR5040		1233	MU2646M		1390	MV1877		
MRA133,B		1235	MU4891		1392	MV1878		1421
MRA163,B		1237	MU4892			MV2101		1425
MRA333,B		1239	MU4893			MV2102		
MRA363,B		1241	MU4894		1392	MV2103		
MRD14B	II	2-264	MUS4987		1394	MV2104		
MRD150		1243	MUS4988		1394	MV2105		
MRD300		1247	MV104		1398	MV2106		
MRD310		1247	MV109		1400	MV2107		
MRD360		1251	MV205		1402	MV2108		
MRD370		1251	MV206		1402	MV2109		
MRD450		1255	MV209		1404	MV2110		
MRD500		1259	MV830		1406	MV2111		
MRD510		1259	MV831			MV2112		
MRD601		1263	MV832			MV2113		
MRD602			MV833			MV2114		
MRD603			MV834			MV2115		1425
MRD604		1263	MV835			MV2201		1429
MRD810		1267	MV836			MV2203		
MRD3050		1269	MV837			MV2205		
MRD3051			MV838			MV2209		1429
MRD3052			MV839			MV2301		1431
MRD3053			MV840		1406	MV2302		
MRD3054			MV1401		1408	MV2303		
MRD3055			MV1403			MV2304		
MRD3056		1269	MV1404			MV2305		
MRF207		1273	MV1405		1408	MV2306		
MRF208		1273	MV1620		1410	MV2307		
MRF209		1273	MV1622			MV2308		1431
MRF215		1277	MV1624			MV3102		1433
MRF216		1280	MV1626			MV3103		1433
MRF221	II	2-443	MV1628			MV3140		1435
MRF225		1283	MV1630		1410	MV3141		1435

DEVICE	VOL	PAGE
MV3142		1435
MV3501		1437
MV3502		
MV3503		
MV3504		
MV3505		
MV3506		
MV3507		1437
MVAM-1		1439
MVI-2097		1441
MVI-2098		
MVI-2099		
MVI-2100		
MVI-2101		
MVI-2102		
MVI-2103		
MVI-2104		
MVI-2105		
MVI-2106		
MVI-2107		
MVI-2108		
MVI-2109		1441
MVS460		1445
MZ500-1		1447
MZ500-2		
MZ500-3		
MZ500-4		
MZ500-5		
MZ500-6		
MZ500-7		
MZ500-8		
MZ500-9		
MZ500-10		
MZ500-11		
MZ500-12		
MZ500-13		
MZ500-14		
MZ500-15		
MZ500-16		
MZ500-17		
MZ500-18		
MZ500-19		
MZ500-20		
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MZ500-26		
MZ500-27		
MZ500-28		
MZ500-29		
MZ500-30		
MZ500-31		
MZ500-32		
MZ500-33		
MZ500-34		
MZ500-35		
MZ500-36		
MZ500-37		
MZ500-38		
MZ500-39		
MZ500-40		1447
MZ605		1449
MZ610		
MZ620		
MZ640		
MZ805		
MZ810		
MZ820		1449
MZ821,A		1452
MZ823,A		
MZ825,A		
MZ827,A		1452
MZ840		1449
MZ935,A,B		1452
MZ936,A,B		
MZ937,A,B		
MZ938,A,B		
MZ941,A,B		
MZ942,A,B		
MZ943,A,B		
MZ944,A,B		1452
MZ1000-1		1460
MZ1000-2		
MZ1000-3		
MZ1000-4		
MZ1000-5		
MZ1000-6		
MZ1000-7		
MZ1000-8		
MZ1000-9		
MZ1000-10		
MZ1000-11		
MZ1000-12		
MZ1000-13		
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MZ1000-15		
MZ1000-16		
MZ1000-17		
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MZ1000-26		
MZ1000-27		
MZ1000-28		
MZ1000-29		
MZ1000-30		
MZ1000-31		
MZ1000-32		
MZ1000-33		
MZ1000-34		
MZ1000-35		
MZ1000-36		1460
MZ1000-37		
MZ2360	I	1-10
MZ2361	I	1-10
MZ2362	I	1-10
MZ3154,A		1452
MZ3155,A		1452
MZ3156,A		1452
MZ4614	I	1-89
MZ4615		
MZ4616		
MZ4617		
MZ4618		
MZ4619		
MZ4620		
MZ4621		
MZ4622		
MZ4623		
MZ4624		
MZ4625		
MZ4626		
MZ4627	I	1-89
MZ5555		1462
MZ5556		
MZ5557		
MZ5558		1462

IN-HOUSE NUMBERED DEVICE SPECIFICATIONS

- DIODES
- OPTOELECTRONICS
- MODULES
- POWER VARACTORS
- RECTIFIERS
- RECTIFIER ASSEMBLIES
- THYRISTORS & TRIGGERS
- TRANSISTORS

.4M. 64FR10
.4M1. 36FR5
.4M1. 36FR2
.4M2. 04FR5
.4M2. 04FR2

For Specifications, See 1N816 Data, Volume I.

.5M2. 4ZS thru .5M200ZS

For Specifications, See 1N5221 Data, Volume II.

1M3.3AZ thru 1M7.5AZ

For Specifications, See 1N3821 Data, Volume I.

1M3.3ZS thru 1M200ZS

For Specifications, See 1N4728 Data, Volume I.

1M6.8Z thru 1M200Z

For Specifications, See 1N3821 Data, Volume I.

5M3.3ZS thru 5M200ZS

For Specifications, See 1N5333 Data, Volume II.

10M6.8Z thru 10M200Z

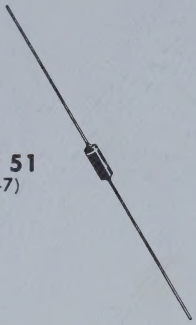
For Specifications, See 1N2970 Data, Volume I.

50M3.9Z thru 50M200Z

For Specifications, See 1N2804 Data, Volume I.

1/4M2.4AZ thru 1/4M200Z (SILICON)

1/4 W
2.4 — 200 V



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region. These devices are in the same 400 mW glass package as the 1N746 and 1N957 Series, but designated 1/4 Watt to allow characterization at a different test current level.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D C Power Dissipation: 1/4 Watt (Derate 1.67 mW/°C Above 25°C)

The type numbers specified have a standard voltage (V_Z) tolerance of ±20%. For closer tolerances, add suffix "10" for ±10% or "5" for ±5%. (3%, 2%, 1% tolerances also available.)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$, $V_F = 1.5$ V max @ 100 mA)

TYPE NO.	NOMINAL ZENER VOLTAGE @ I_{ZT} (V_Z) VOLTS	TEST CURRENT (I_{ZT}) mA	MAXIMUM ZENER IMPEDANCE (Z_{ZT}) @ I_{ZT} ohms	MAXIMUM DC ZENER CURRENT (I_{ZM}) mA	REVERSE LEAKAGE CURRENT I_R MAX (μA)	TEST VOLTAGE Vdc* V_{R1}	TEST VOLTAGE Vdc* V_{R2}
1/4M2.4AZ	2.4	10	60	70	75	1	1
1/4M2.7AZ	2.7	10	60	65	75	1	1
1/4M3.0AZ	3.0	10	55	60	50	1	1
1/4M3.3AZ	3.3	10	55	55	50	1	1
1/4M3.6AZ	3.6	10	50	52	50	1	1
1/4M3.9AZ	3.9	10	50	49	25	1	1
1/4M4.3AZ	4.3	10	45	46	25	1.5	1.5
1/4M4.7AZ	4.7	10	35	42	10	1.5	1.5
1/4M5.1AZ	5.1	10	25	39	5	1.5	1.5
1/4M5.6AZ	5.6	10	20	36	5	1.5	1.5
1/4M6.2AZ	6.2	10	15	33	5	3.5	3.5
1/4M6.8Z	6.8	9.2	7.0	33	150	5.2	4.9
1/4M7.5Z	7.5	8.3	8.0	30	75	5.7	5.4
1/4M8.2Z	8.2	7.6	9.0	26	50	6.2	5.9
1/4M9.1Z	9.1	6.9	10	24	25	6.9	6.6
1/4M10Z	10	6.3	11	21	10	7.6	7.2
1/4M11Z	11	5.7	13	19	5	8.4	8.0
1/4M12Z	12	5.2	15	18	5	9.1	8.6
1/4M13Z	13	4.8	18	16	5	9.9	9.4
1/4M14Z	14	4.5	20	15	5	10.6	10.1
1/4M15Z	15	4.2	22	14	5	11.4	10.8
1/4M16Z	16	3.9	24	13	5	12.2	11.5
1/4M17Z	17	3.7	26	12.5	5	13.0	12.2
1/4M18Z	18	3.5	28	11.5	5	13.7	13.0
1/4M19Z	19	3.3	30	11.0	5	14.4	13.7
1/4M20Z	20	3.1	33	10.5	5	15.2	14.4
1/4M22Z	22	2.8	40	9.5	5	16.7	15.8
1/4M24Z	24	2.6	46	9.0	5	18.2	17.3
1/4M25Z	25	2.5	50	8.0	5	19.0	18.0
1/4M27Z	27	2.3	58	7.5	5	20.6	19.4
1/4M30Z	30	2.1	70	7.0	5	22.8	21.6

*V_{R1} — Test Voltage for 5% Tolerance Device V_{R2} — Test voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$, $V_F = 1.5$ V max @ 100 mA) (continued)

TYPE NO.	NOMINAL ZENER VOLTAGE @ I_{ZT} (V_Z) VOLTS	TEST CURRENT (I_{ZT}) mA	MAXIMUM ZENER IMPEDANCE (Z_{ZT}) @ I_{ZT} ohms	MAXIMUM DC ZENER CURRENT (I_{ZM}) mA	REVERSE LEAKAGE CURRENT	
					I_R MAX (µA)	TEST VOLTAGE Vdc*
						V_{R1}	V_{R2}
1/4M33Z	33	1.9	85	6.5	5	25.1	23.8
1/4M36Z	36	1.7	100	6.0	5	27.4	25.9
1/4M39Z	39	1.6	120	5.0	5	29.7	28.1
1/4M43Z	43	1.5	140	4.8	5	32.7	31.0
1/4M45Z	45	1.4	150	4.5	5	34.2	32.4
1/4M47Z	47	1.3	160	4.3	5	35.8	33.8
1/4M50Z	50	1.2	180	4.1	5	38.0	36.0
1/4M52Z	52	1.2	200	4.0	5	39.5	37.4
1/4M56Z	56	1.1	230	3.8	5	42.6	40.3
1/4M62Z	62	1.0	290	3.3	5	47.1	44.6
1/4M68Z	68	0.92	350	3.0	5	51.7	49.0
1/4M75Z	75	0.83	450	2.8	5	56.0	54.0
1/4M82Z	82	0.76	550	2.5	5	62.2	59.0
1/4M91Z	91	0.69	700	2.3	5	69.2	65.5
1/4M100Z	100	0.63	900	2.0	5	76.0	72.0
1/4M105Z	105	0.60	1000	1.9	5	79.8	75.6
1/4M110Z	110	0.57	1200	1.8	5	83.6	79.2
1/4M120Z	120	0.52	1500	1.7	5	91.2	86.4
1/4M130Z	130	0.48	1900	1.5	5	98.8	93.6
1/4M140Z	140	0.45	2200	1.4	5	106.4	100.8
1/4M150Z	150	0.42	2500	1.3	5	114.0	108.0
1/4M175Z	175	0.36	3300	1.1	5	133.0	126.0
1/4M200Z	200	0.31	4300	1.0	5	152.0	144.0

*V_{R1} — Test Voltage for 5% Tolerance Device V_{R2} — Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 — Nominal zener voltages between those shown.

2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.

  a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.

  b. Two or more units matched to one another with any specified tolerance.

3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

BB105A (SILICON)
BB105B
BB105G

VVC

SILICON EPICAP DIODES

. . . designed in the new low-inductance mini-L package for high volume requirements of UHF and VHF TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

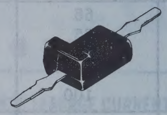
- Guaranteed Minimum Q Values at VHF and UHF Frequencies
- Controlled and Uniform Tuning Ratio
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to your specified conditions along the entire tuning range.

If you require BB150A and BB105B matched to ±1.5% between 3.0 and 25 Volts, add "M" to the device title (i.e., BB105BM). BB105G can be ordered matched to ±3.0% by adding M to the device title. For any other matched tolerances or conditions, please contact your local Motorola Representative.

VOLTAGE VARIABLE CAPACITANCE DIODES

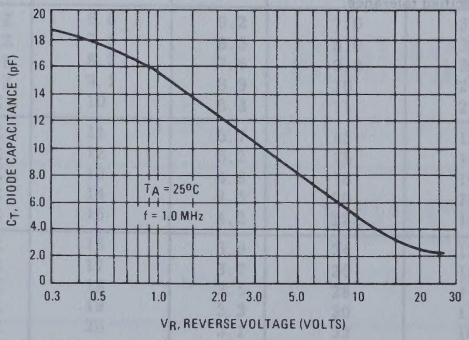
30 VOLTS

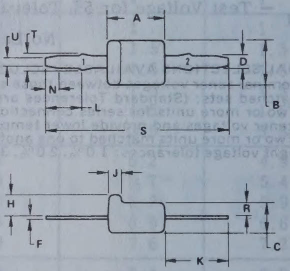


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 4.0	mW mW/^oC
Junction Temperature	T_J	+125	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC

FIGURE 1 – DIODE CAPACITANCE





PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

BB105A, BB105B, BB105G (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic-All Types	Symbol	Min	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	—	Vdc
Reverse Voltage Leakage Current (VR = 28 V) (VR = 28 V) $T_A = 60^oC$	I_R	—	50.0 0.5	nAdc μAdc
Series Inductance (f = 250 MHz)	L_S	—	3.0	nH
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	—	400	ppm/°C

Device Type	C_T V_R = 25 Vdc pF		Q f = 100 MHz C_T = 9 pF	R_S Ohms	C_3/C_{25}		Stripe on Body	Ridge Stripe
	Min	Max	Min	Max	Min	Max	Color	Color
BB105A	2.3	2.8	225	0.8	4.0	5	Blue	White
BB105B	2.0	2.3	225	0.8	4.5	6	Yellow	White
BB105G	1.8	2.8	150	1.2	4.0	6	Green	White

FIGURE 2 – FIGURE OF MERIT

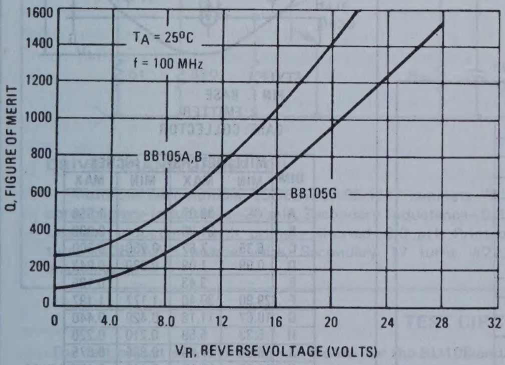
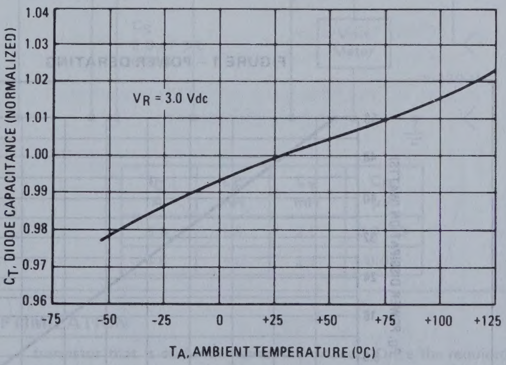


FIGURE 3 – DIODE CAPACITANCE



BU105

For Specifications, See MJ105 Data.

BU108 (SILICON)
MJ3480

HORIZONTAL DEFLECTION SILICON TRANSISTORS

. . . designed for use in large screen color television receivers.

- Collector-Emitter Voltage – V_{CER} = 1500 Vdc
- Collector Current – I_C = 5.0 Adc
- Fall Time @ I_C = 4.5 Adc – t_f = 0.7 μs (Typ) • t_f = 1.0 μs (Max)

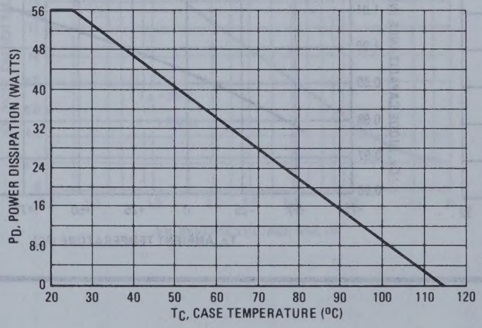
MAXIMUM RATINGS

Rating	Symbol	BU108	MJ3480	Unit
Collector-Emitter Voltage	V_{CEO}	750	700	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	1500	1300	Vdc
Collector-Base Voltage	V_{CB}	1500	1300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	7.0	Vdc
Collector Current – Continuous – Peak	I_C	5.0 10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	56 0.625		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +115		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.6	°C/W

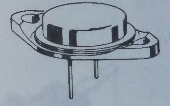
FIGURE 1 – POWER DERATING

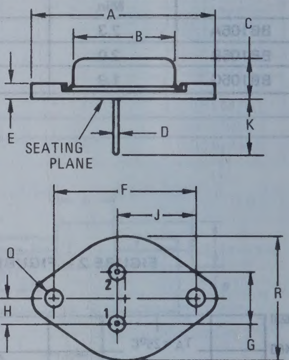


5.0 AMPERE

TRIPLE DIFFUSED POWER TRANSISTORS NPN SILICON

1300, 1500 VOLTS
56 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.
CASE 11

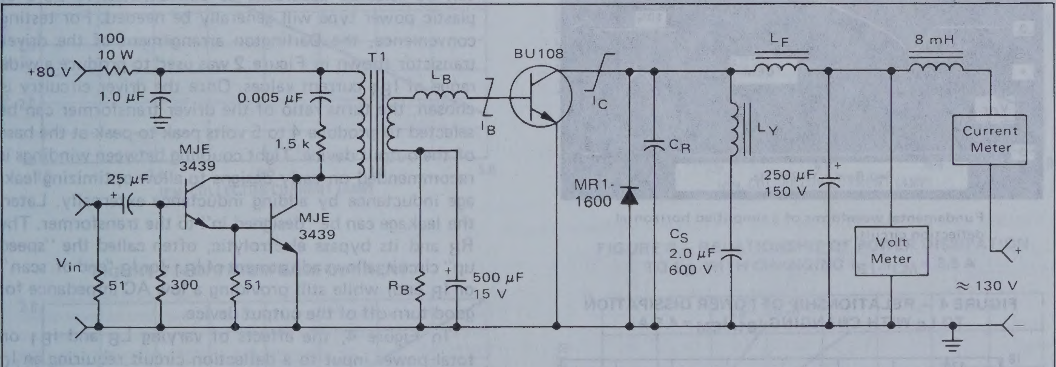
ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0) BU108 MJ3480	$V_{CEO(sus)}$	 750 700	 – –	 – –	Vdc
Collector Cutoff Current (V_{CE} = 1500 Vdc, V_{BE} = 0) BU108 (V_{CE} = 1300 Vdc, V_{BE} = 0) MJ3480	I_{CES}	 – –	 – –	 1.0 1.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 4.5 Adc, I_B = 2.0 Adc)	$V_{CE(sat)}$	–	–	5.0	Vdc
Base Emitter Saturation Voltage (I_C = 4.5 Adc, I_B = 2.0 Adc)	$V_{BE(sat)}$	–	–	1.5	Vdc
Second Breakdown Collector Current with Base Forward Biased (t = 1.0 s, V_{CE} = 100 Vdc)	$I_{S/b}$	200	–	–	mAdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2) (I_C = 0.1 Adc, V_{CE} = 5.0 Vdc, f_{test} = 1.0 MHz)	f_T	–	7.5	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	125	–	pF
SWITCHING CHARACTERISTICS					
Fall Time (I_C = 4.5 Adc, I_{B1} = 1.8 Adc, L_B = 10 µH, See Figure 2)	t_f	–	0.7	1.0	µs

(1) Pulse Test: Pulse Width 300 µs, Duty Cycle ≈ 2.0%

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – TEST CIRCUIT



DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A05-1/4" laminate "E" iron core. Primary Inductance–39 mH, Secondary Inductance–0.22 mH, Leakage inductance with primary shorted–2.0 µH. Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

I_C A	L_F mH	L_Y mH	C_R µF
3.5	1.8	2.5	0.0133
4.5	1.0	2.5	0.02

TEST CIRCUIT OPTIMIZATION

The test circuit and operating waveforms for the BU108 and MJ3480 transistors are shown in Figures 2 and 3. The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, power supply input. Excessive power input can be caused by a variety of problems, but it is the dissipation in the transistor that is of fundamental importance. Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the input power is proportional to current. No adjustment of the test apparatus is required.

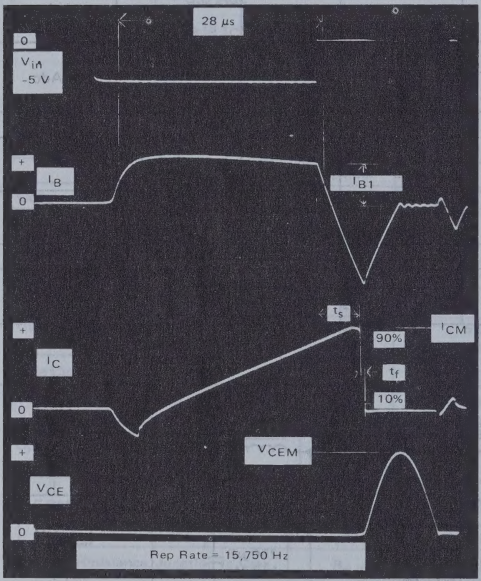
BASIC CONSIDERATIONS

The primary consideration when choosing a deflection transistor for a conventional (parallel-connected) circuit, as shown in Figure 2, is voltage capability. The flyback voltage that the device will be subjected to is a relatively predictable value with respect to the main power supply voltage. This voltage pulse, shown in Figure 3, will usually be 8 times the 130-volt power supply voltage or approximately 1000 volts, but may be varied slightly by adjusting retrace time and flyback tuning. For this reason, high voltage devices are particularly useful in cost conscious solid-state receivers as they permit the use of an off-the-line half wave power supply.

The power supply used in the circuit of Figure 2, was chosen to produce approximately a 1000 V collector pulse on the transistor, a conservative value, recommended for unregulated applications.

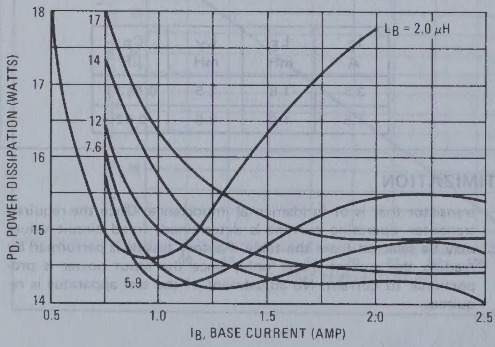
The values of yoke inductance (L_Y), flyback primary inductance (L_F), retrace capacitor (C_R) and "S" shaping capacitor (C_S) are shown for operating collector currents of 3.5 A which is suitable for 90° color and 110° large screen black and white receivers, and 4.5 A for 110° color receivers. Peak collector currents to 10 A may be handled by these transistors. The most efficient application results when the power supply voltage is held constant. Adjustments of the amount of deflection can then be made by raising or lowering L_Y and L_F. $L_Y I_Y$ is constant for the fixed voltage situation, and actual deflection is proportional to $I_Y \sqrt{L_Y}$. Values of C_S and C_R must be varied inversely with L_Y to maintain retrace and "S" shaping periods.

FIGURE 3 – TEST CIRCUIT WAVEFORMS



Fundamental waveforms of a simplified horizontal deflection circuit.

FIGURE 4 – RELATIONSHIP OF POWER DISSIPATION TO L_B WITH CHANGING I_{B1}, I_{CM} = 4.5 A



TEST CIRCUIT VALUES

The driver power supply and driver transistor type can be selected according to convenience. A TO-5 or plastic power type will generally be needed. For testing convenience, the Darlington arrangement of the driver transistor shown in Figure 2 was used to produce a wide range of I_{B1} current values. Once the driver circuitry is chosen, the turns ratio of the driver transformer can be selected to produce 4 to 5 volts peak-to-peak at the base of the output device. Tight coupling between windings is recommended on early designs to allow optimizing leakage inductance by adding inductance externally. Later, the leakage can be "designed in" to the transformer. The R_B and its bypass electrolytic, often called the "speed up" circuit, allows adjustment of I_{B1} (or I_B "end of scan" or I_B end) while still providing a low AC impedance for good turn-off of the output device.

In Figure 4, the effects of varying L_B and I_{B1} on total power input to a deflection circuit requiring an I_C of 4.5 A are shown. Note that an optimum L_B can be found which will produce low dissipation over a wide range of I_{B1}. This is desirable in order to produce efficient operation over a wide range of circuit component tolerances. Likewise, best L_B also gives the least sensitivity to output transistor h_{FE}.

The best value of L_B found in Figure 4 is 12 µH. This is the sum of the actual leakage inductance of the driver transformer (secondary inductance with primary shorted) and an external L if necessary. The value of I_{B1} is approximately 1.75 A achieved in a typical device by using R_B = 2.3 Ω, which was derived experimentally. These are the choices recommended for the test fixture when the transistor is used at I_{CM} = 4.5 A.

Today many TV receivers operate with an I_{CM} of approximately 3.5 A, Figure 8 shows the relationship of power dissipation to L_B, with changing I_{B1}, when I_C of 3.5 A is required.

The best value of L_B, found in Figure 9 is 22 μH. This value is the sum of the driver transformer leakage inductance and an external inductance if necessary. The best value of I_{B1} is approximately 1.15 A, with an R_B of 3.2 Ω. These are the choices recommended for the test fixture when the transistor is used at I_{CM} = 3.5 A.

For other values of I_{CM} the drive circuit components must be changed. Figures 5, 6 and 7 show the values of L_B and I_{B1} which should be used. The value of R_B which will be required to produce the corresponding I_{B1} is also given, but, it is not an independent variable.

PERFORMANCE

Shown in Figures 9 and 10 are the typical results that will be obtained with the test circuit at various operating conditions.

INTERRELATION OF BASE RESISTANCE, BASE INDUCTANCE AND BASE CURRENT

FIGURE 5 – OPTIMUM BASE RESISTANCE

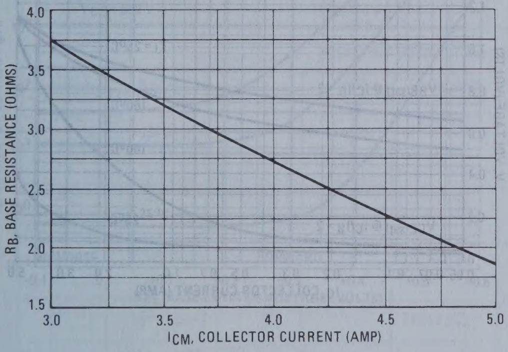


FIGURE 6 – OPTIMUM BASE INDUCTANCE

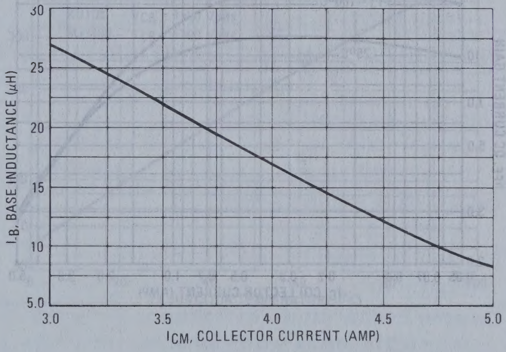


FIGURE 7 – OPTIMUM BASE CURRENT

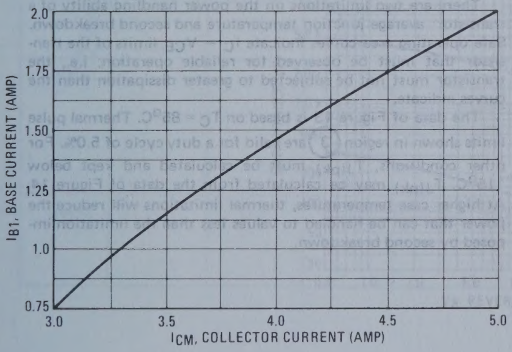


FIGURE 8 – RELATIONSHIP OF POWER DISSIPATION TO L_B, WITH CHANGING I_{B1}, I_{CM} = 3.5 A

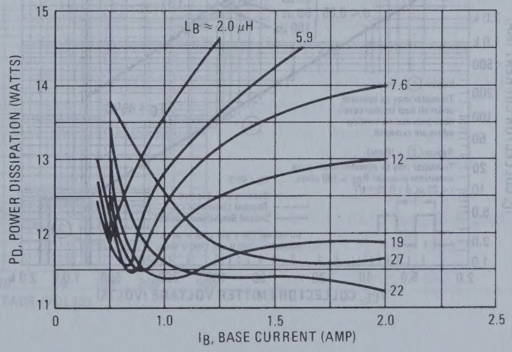


FIGURE 9 – INTERRELATION OF t_f, FALL TIME AND t_s, STORAGE TIME

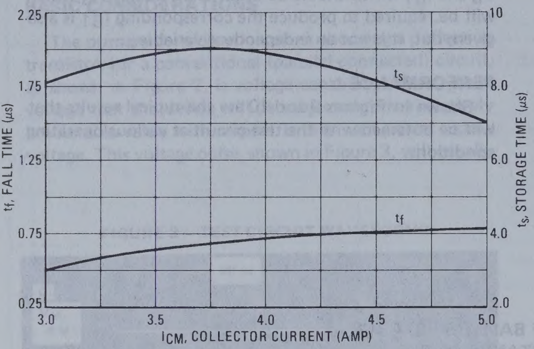


FIGURE 10 – EFFECT OF COLLECTOR CURRENT ON INPUT POWER

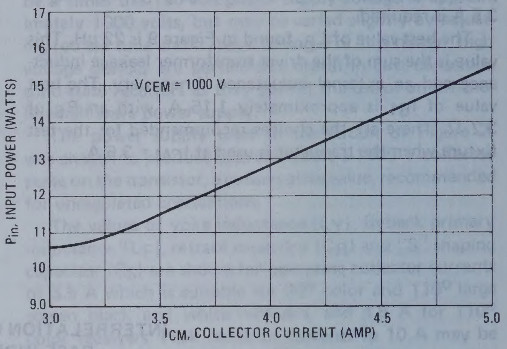


FIGURE 11 – DC CURRENT GAIN

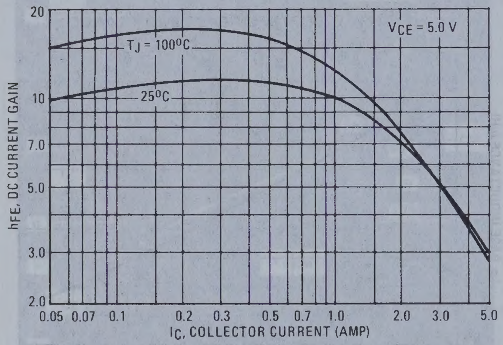


FIGURE 12 – "ON" VOLTAGES

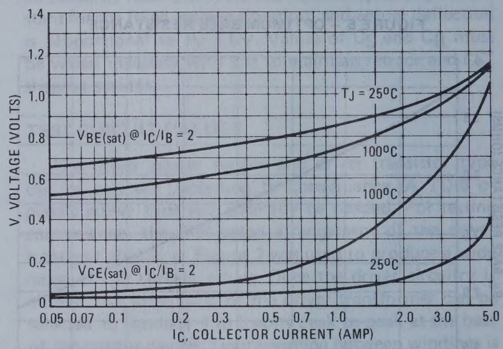
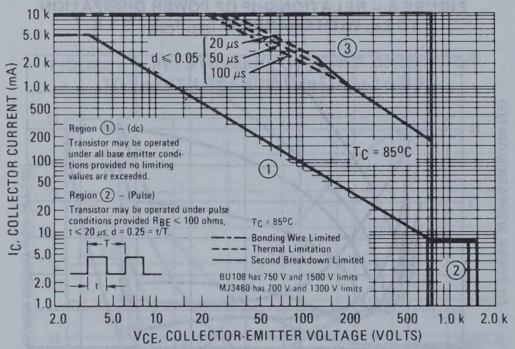


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



Region ① – (dc)
Transistor may be operated under all base emitter conditions provided no limiting values are exceeded.

Region ② – (Pulse)
Transistor may be operated under pulse conditions provided $R_{BE} \leq 100$ ohms, $t \leq 20\ \mu s$, $d = 0.25 = t/T$.

BU108 has 750 V and 1500 V limits
MJ3480 has 700 V and 1300 V limits

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on $T_C = 85°C$. Thermal pulse limits shown in region ③ are valid for a duty cycle of 5.0%. For other conditions, $T_{J(pk)}$ must be calculated and kept below 115°C. $T_{J(pk)}$ may be calculated from the data of Figure 14. At higher case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitation imposed by second breakdown.

FIGURE 14 – THERMAL RESPONSE

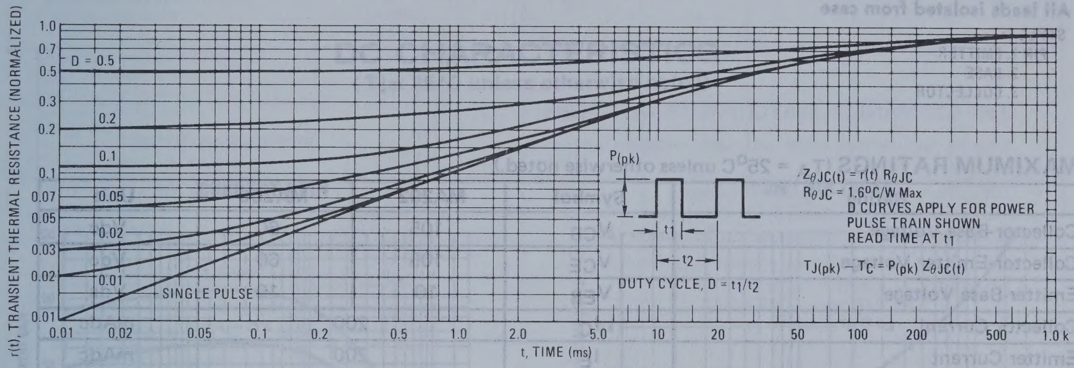


FIGURE 15 – COLLECTOR CUT-OFF REGION

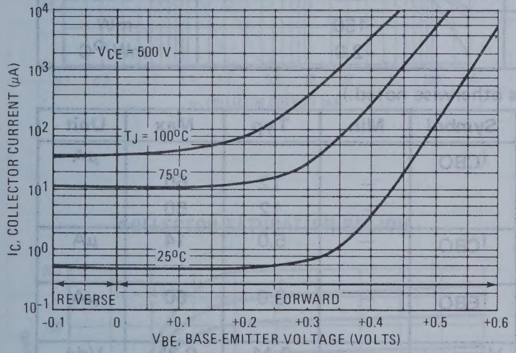


FIGURE 16 – COLLECTOR-BASE LEAKAGE CURRENT

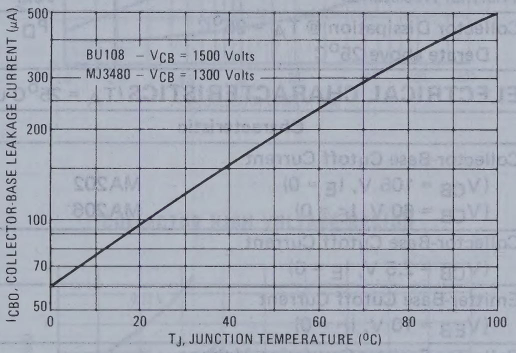
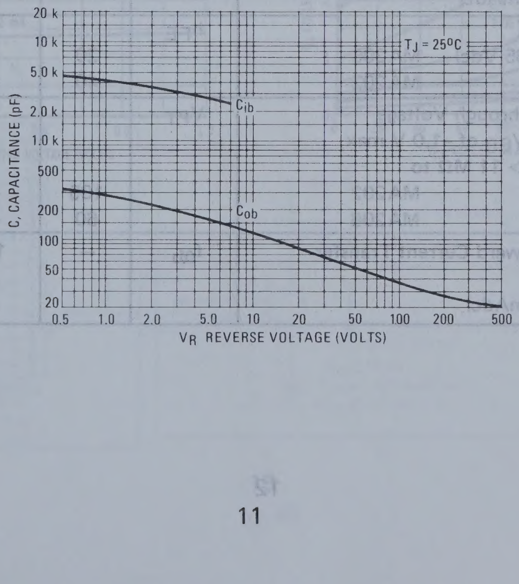
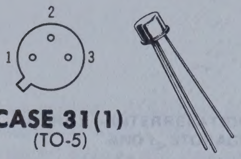


FIGURE 17 – CAPACITANCE



MA202, MA206 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated from case

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Germanium PNP transistor designed for high-voltage applications in the audio frequency range, such as neon driver, solenoid or relay driver applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	MA202	MA206	Unit
Collector-Base Voltage	V_{CB}	105	60	Vdc
Collector-Emitter Voltage	V_{CE}	105	60	Vdc
Emitter-Base Voltage	V_{EB}	10	10	Vdc
Collector Current	I_C	200		mAdc
Emitter Current	I_E	200		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		°C
Thermal Resistance	$R_{\theta JA}$	0.5		°C/mW
Collector Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0		mW mW/°C

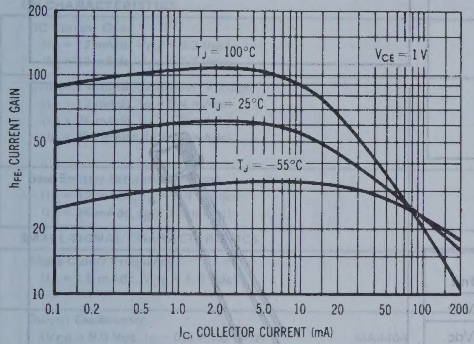
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 105 V, I_E = 0) (V_{CB} = 60 V, I_E = 0)	 MA202 MA206	I_{CBO}	 — —	 12 12	 50 50	μA
Collector-Base Cutoff Current (V_{CB} = 2.5 V, I_E = 0)		I_{CBO}	—	5.0	14	μA
Emitter-Base Cutoff Current (V_{EB} = 10 V, I_C = 0)		I_{EBO}	—	3.0	50	μA
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	—	0.11	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	—	0.22	0.40	Vdc
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 0.35 Vdc)	 MA206 MA202	h_{FE}	 20 40	 — —	 — —	—
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1.0 V max, using instrument with $Z_{in} > 11$ MΩ to measure V_{BE})	 MA202 MA206	V_{PT}	 105 60	 — —	 — —	Vdc
Small-Signal Short-Circuit Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6.0 Vdc, I_E = 1.0 mAdc)		$f_{\alpha b}$	—	1.0	—	MHz

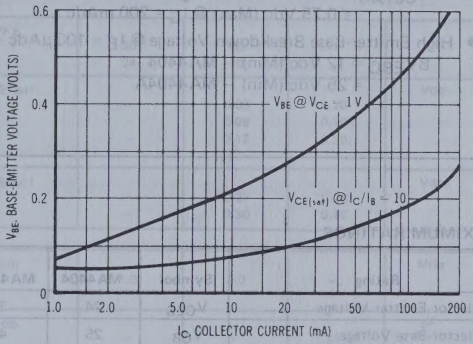
DC CHARACTERISTICS

(T_J= 25°C unless otherwise noted)

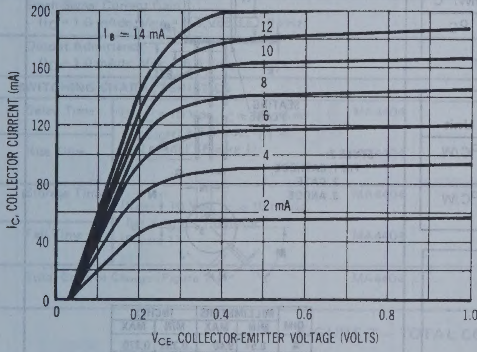
CURRENT GAIN



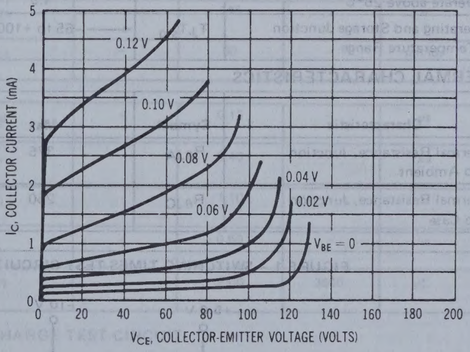
"ON" VOLTAGES



COLLECTOR SATURATION REGION



COLLECTOR HIGH VOLTAGE REGION



MA4404, MA4404A (GERMANIUM)

PNP GERMANIUM SWITCHING TRANSISTORS

. . . designed for medium-speed saturated switching and chopper applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.2 Vdc (Max) @ I_C = 24 mAdc
  = 0.25 Vdc (Max) @ I_C = 200 mAdc
- High Emitter-Base Breakdown Voltage @ I_E = 100 μAdc –
  BV_{EBO} = 12 Vdc (Min) – MA4404
  = 25 Vdc (Min) – MA4404A

PNP GERMANIUM SWITCHING TRANSISTORS

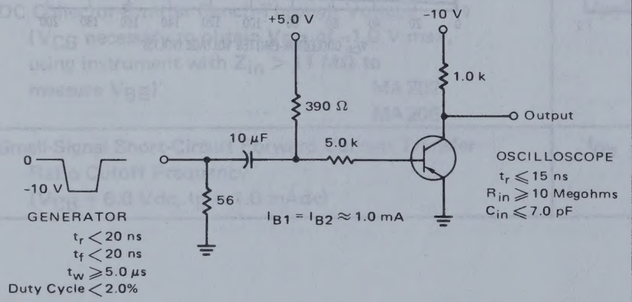
MAXIMUM RATINGS

Rating	Symbol	MA4404	MA4404A	Unit
Collector-Emitter Voltage	V_{CES}	24	35	Vdc
Collector-Base Voltage	V_{CB}	25	40	Vdc
Emitter-Base Voltage	V_{EB}	12	25	Vdc
Collector Current-Continuous	I_C	350		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 2.67		mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4.0		mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	←— -65 to +100 —→		^oC

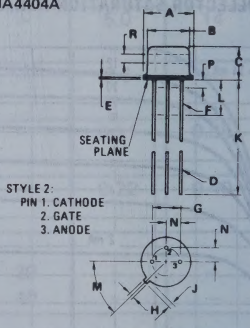
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	375	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	$^oC/W$

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT


+5.0 V
-10 V
1.0 k
390 Ω
Output
10 μF
5.0 k
0
-10 V
56
GENERATOR
$t_r < 20$ ns
$t_f < 20$ ns
$t_w \geqslant 5.0$ μs
Duty Cycle < 2.0%
$I_{B1} = I_{B2} \approx 1.0$ mA
OSCILLOSCOPE
$t_r \leqslant 15$ ns
$R_{in} \geqslant 10$ Megohms
$C_{in} \leqslant 7.0$ pF

MA4404
MA4404A


A
B
R
P
C
E
F
L
SEATING PLANE
K
D
STYLE 2:
PIN 1. CATHODE
2. GATE
3. ANODE
G
N
N
1
2
3
M
J
H

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

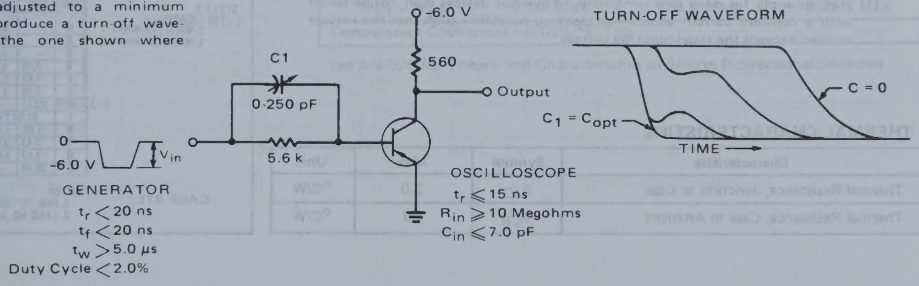
All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	MA4404, MA4404A	BV_{CES}	24 35	– –	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 20 μAdc, I_E = 0)	MA4404, MA4404A	BV_{CBO}	25 40	– –	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	MA4404, MA4404A	BV_{EBO}	12 25	– –	– –	Vdc
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0) (V_{CB} = 12 Vdc, I_E = 0, T_A = 80°C)		I_{CBO}	– –	– –	10 500	μAdc
Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	0.5	5.0	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.2 Vdc) (I_C = 24 mAdc, V_{CE} = 0.2 Vdc)		h_{FE}	30 24	80 70	– –	–
Collector-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc) (I_C = 200 mAdc, I_B = 20 mAdc)		$V_{CE(sat)}$	– – –	0.09 0.09 0.13	0.20 0.20 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	– –	0.27 0.30	0.38 0.40	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Alpha Cutoff Frequency (I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc)		f_{hfb}	1.0	2.0	–	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz) (V_{CB} = 6.0 Vdc, I_E = 1.0 mAdc, f = 2.0 MHz)	MA4404 MA4404A	C_{ob}	– –	– 4.0	25 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{ie}	–	4.0	–	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{re}	–	8.5	–	$X10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{fe}	–	145	–	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{oe}	–	50	–	μmhos
SWITCHING CHARACTERISTICS						
Delay Time (V_{CC} = 10 Vdc, $I_C \approx$ 10 mAdc) $V_{BE(off)}$ = 5.0 Vdc, $I_{B1} \approx$ 1.0 mAdc) (Figure 1)	MA4404	t_d	–	0.13	–	μs
Rise Time	MA4404	t_r	–	0.40	–	μs
Storage Time (V_{CC} = 10 Vdc, $I_C \approx$ 10 mAdc, $I_{B1} = I_{B2} \approx$ 1.0 mAdc) (Figure 1)	MA4404	t_s	–	1.10	–	μs
Fall Time	MA4404	t_f	–	0.60	–	μs
Total Control Charge (Figure 2)	MA4404	Q_T	–	3000	3600	pC

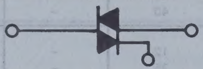
FIGURE 2 – TOTAL CONTROL CHARGE TEST CIRCUIT



Capacitor C_1 is adjusted to a minimum value which will produce a turn-off waveform similar to the one shown where $C_1 = C_{opt}$.

$Q_T = C_{opt} V_{in}$

MAC5 SERIES (SILICON)
MAC6 SERIES



TRIACS (THYRISTORS)

10 AMPERES RMS

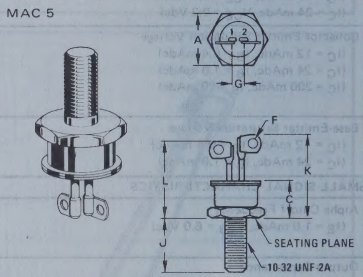
25 THRU 600 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- Glass Passivated Junctions
- Low "on" Voltage – V_{TM} = 1.3 V (Typ) @ 14 A Peak
- Four Mode and Isolated Stud Versions Available (2N6139 Series)

MAC 5



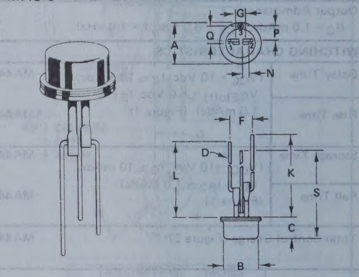
STYLE 2:
PIN 1. GATE
2. MAIN TERMINAL 1
STUD: MAIN TERMINAL 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	11.10	–	0.437
C	–	7.87	–	0.310
F	1.78 TYP		0.070 TYP	
G	2.29	2.79	0.090	0.110
J	10.72	11.48	0.422	0.452
K	–	16.76	–	0.660
L	–	15.49	–	0.610

CASE 86

NOTE:
1. DIM "G" MEASURED AT CAN.

MAC 6



STYLE 2:
PIN 1. GATE
2. MAIN TERMINAL 1
3. MAIN TERMINAL 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	10.92	–	0.430
B	–	8.89	–	0.350
C	–	5.97	–	0.235
D	0.76	0.86	0.030	0.034
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
K	33.53	–	1.320	–
L	31.50 TYP		1.240 TYP	
N	1.65	1.91	0.065	0.075
P	3.43	3.68	0.135	0.145
Q	4.57	5.08	0.180	0.200
S	30.48	–	1.20	–

CASE 87L

NOTES:
1. DIM. "G" MEASURED AT CAN.
2. LEAD NO. 3 ±7.5° DISPLACEMENT.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (1) (T_J = 100°C)	V_{DRM}		Volts
MAC5 and MAC6 –1		25	
–2		50	
–3		100	
–4		200	
–5		300	
–6		400	
–7		500	
–8		600	
On-State Current RMS (T_C = 75°C)	$I_{T(RMS)}$	10	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
Peak Gate Power	P_{GM}	10	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque, MAC5	–	15	in. lb.

(1) Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

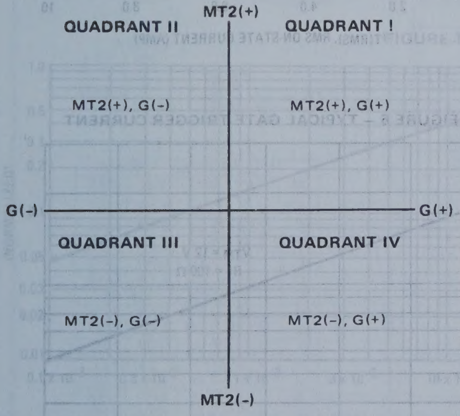
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	50	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 100°C, Gate Open	I_{DRM}	–	–	2.0	mA
On-State Voltage (Either Direction) I_{TM} = 14 A Peak	V_{TM}	–	1.3	1.8	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms MT2(+)G(+); MT2(-)G(-)	I_{GT}	–	–	50	mA
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms MT2(+)G(+); MT2(-)G(-)	V_{GT}	–	1.0	2.5	Volts
Gate Trigger Voltage, Continuous dc – All Modes Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 100°C	V_{GD}	0.2	–	–	Volts
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 100 mA	I_H			50	mA
Turn-On Time I_{TM} = 14 Adc, I_{GT} = 100 mAdc	t_{on}	–	1.5	–	μs
Blocking Voltage Application Rate at Commutation @ V_{DRM}, T_J = 75°C, Gate Open	dv/dt	–	5.0	–	V/μs

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$V_{S1} - V_{S2}$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient = 0.02%/°C Typ			

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

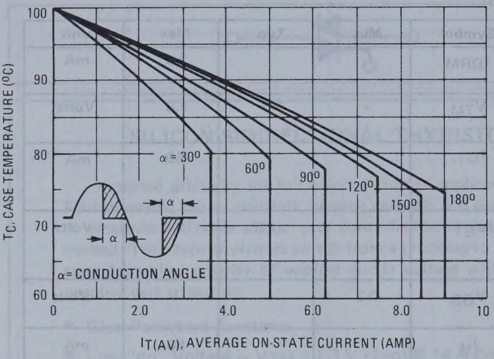


FIGURE 2 – RMS CURRENT DERATING

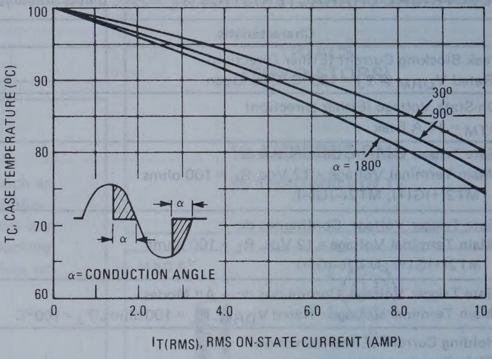


FIGURE 3 – POWER DISSIPATION

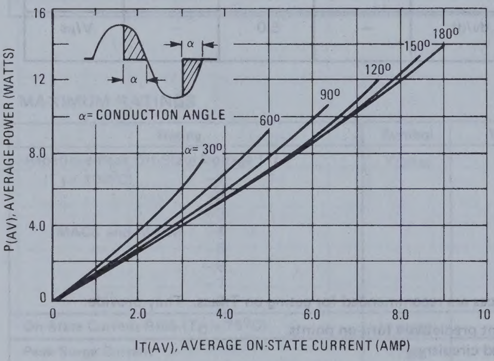


FIGURE 4 – POWER DISSIPATION

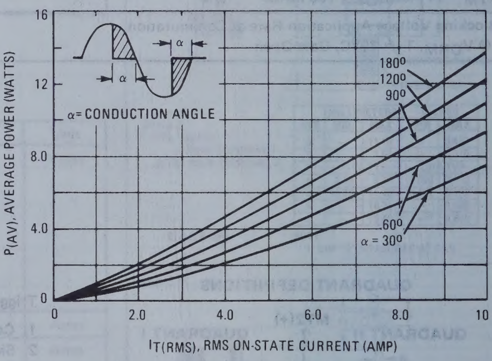


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

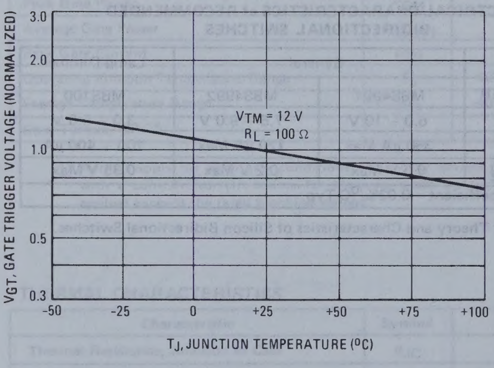


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT

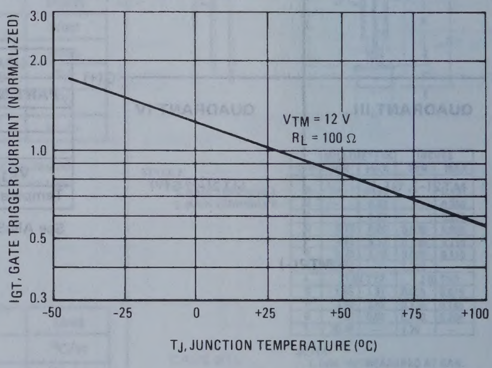


FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

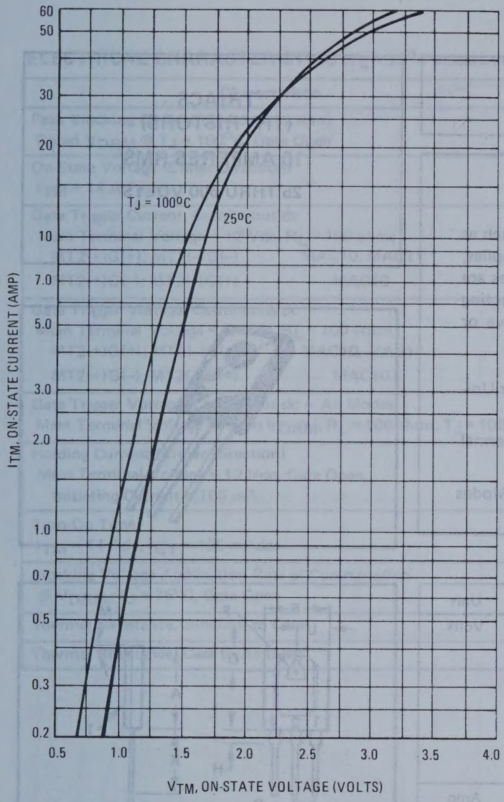


FIGURE 8 – TYPICAL HOLDING CURRENT

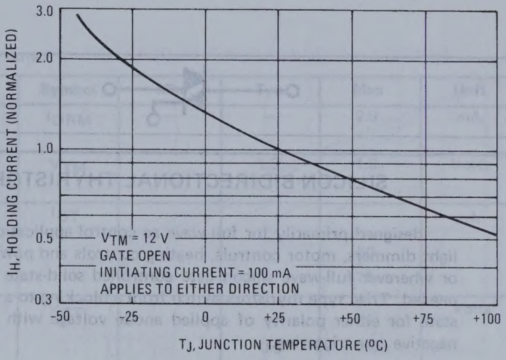


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

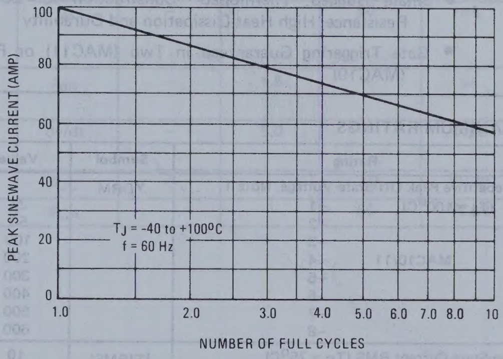
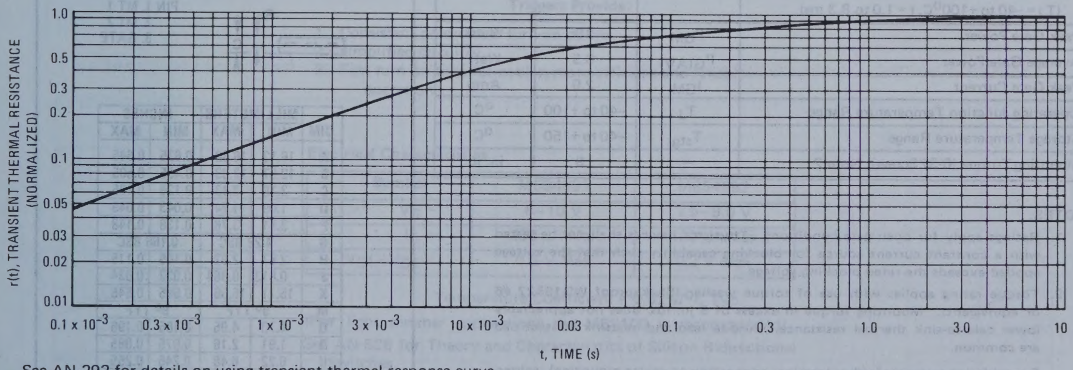
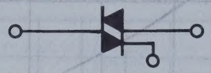


FIGURE 10 – THERMAL RESPONSE



See AN-292 for details on using transient thermal response curve.

MAC10-1 thru MAC10-8 (SILICON)
MAC11-1 thru MAC11-8



TRIACS (THYRISTORS)

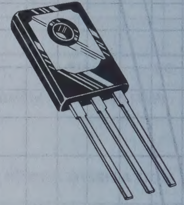
10 AMPERES RMS

25 THRU 600 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- All Diffused and Passivated Junctions for Greater Parameter Uniformity and Stability
- Small, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability
- Gate Triggering Guaranteed in Two (MAC11) or Four Modes (MAC10)



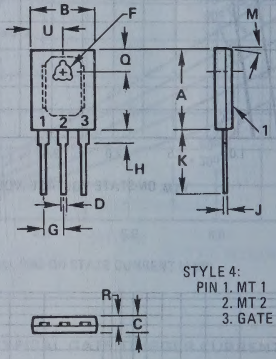
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage, Note 1 (T_J = 100°C) –1 –2 –3 MAC10/11 –4 –5 –6 –7 –8	V_{DRM}	 25 50 100 200 300 400 500 600	Volts
On-State Current RMS (T_C = 75°C)	$I_{T(RMS)}$	10	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
Peak Gate Power	P_{GM}	10	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 Screw), Note 2	—	8	in. lb.

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +200°C. For optimum results, an activated flux (oxide removing) is recommended.



STYLE 4:
PIN 1. MT 1
2. MT 2
3. GATE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

CASE 90-05

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

Volume 3 Motorola P.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 100°C, Gate Open	I_{DRM}	–	–	2.0	mA
On-State Voltage (Either Direction) I_{TM} = 14 A Peak	V_{TM}	–	1.3	1.8	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms	I_{GT}				mA
MT2(+)G(+); MT2(–)G(–) MAC10, MAC11		–	–	50	
MT2(+)G(–); MT2(–)G(+) MAC10		–	–	75	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 12 Vdc, R_L = 100 ohms	V_{GT}				Volts
MT2(+)G(+); MT2(–)G(–) MAC10, MAC11		–	0.9	2.0	
MT2(+)G(–); MT2(–)G(+) MAC10		–	1.0	2.5	
Gate Trigger Voltage, Continuous dc — All Modes Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 100°C	V_{GD}	0.2	–	–	Volts
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, Initiating Current = 100 mA	I_H	–	–	50	mA
Turn-On Time I_{TM} = 14 Adc, I_{GT} = 100 mAdc	t_{on}	–	1.5	–	μs
Blocking Voltage Application Rate at Commutation @ V_{DRM}, T_J = 75°C, Gate Open	dv/dt	–	5.0	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–	–	2.0	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	–	–	50	°C/W

MBS4991/MBS4992
Recommended for Triac Triggering

Triggers Provide:

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

Electrical Characteristics

Symbol	MBS4991	MBS4992
V_S =	6–10 V	7.5–9.0 V
I_S =	350 μA Max	120 μA Max
$V_{S1}-V_{S2}$ =	0.5 V Max	0.2 V Max

Temperature Coefficient = 0.02%/°C Typ

(For light dimmer applications the MBS100 is recommended).

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – AVERAGE CURRENT DERATING

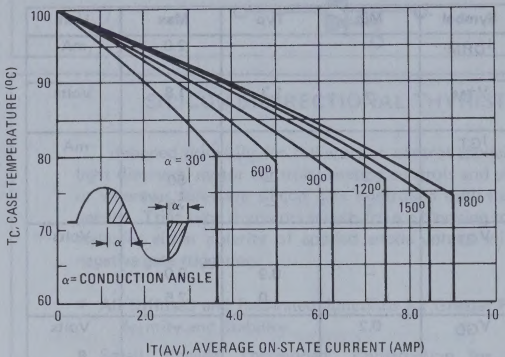


FIGURE 2 – RMS CURRENT DERATING

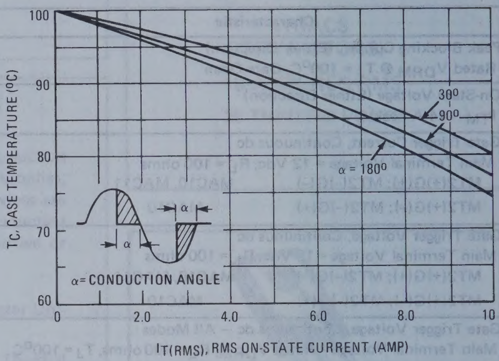


FIGURE 3 – POWER DISSIPATION

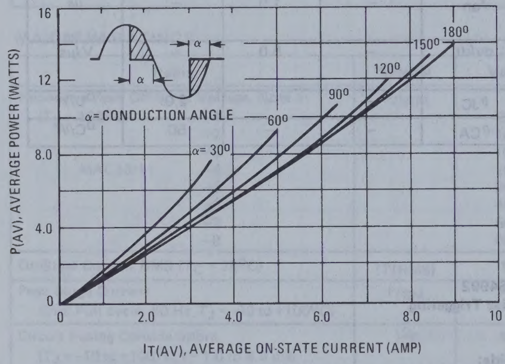


FIGURE 4 – POWER DISSIPATION

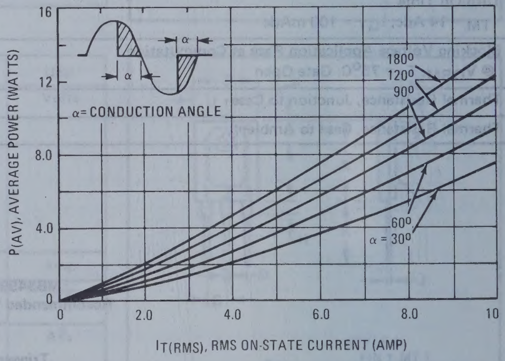


FIGURE 5 – TYPICAL GATE TRIGGER VOLTAGE

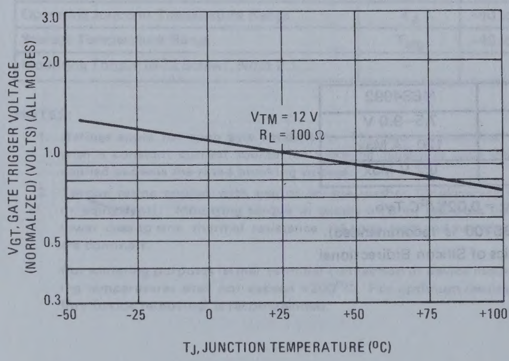
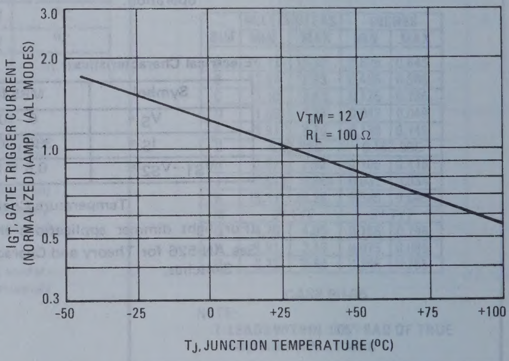


FIGURE 6 – TYPICAL GATE TRIGGER CURRENT



Volume 3 Motorola P

FIGURE 7 – MAXIMUM ON-STATE CHARACTERISTICS

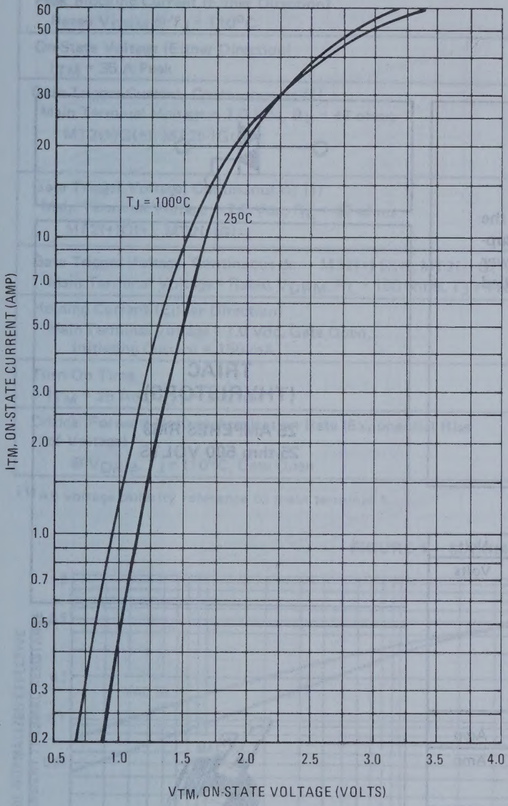


FIGURE 8 – TYPICAL HOLDING CURRENT

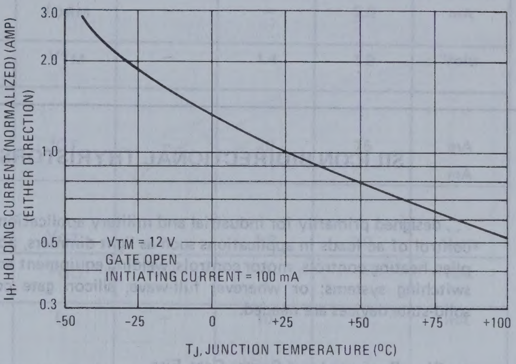


FIGURE 9 – MAXIMUM ALLOWABLE SURGE CURRENT

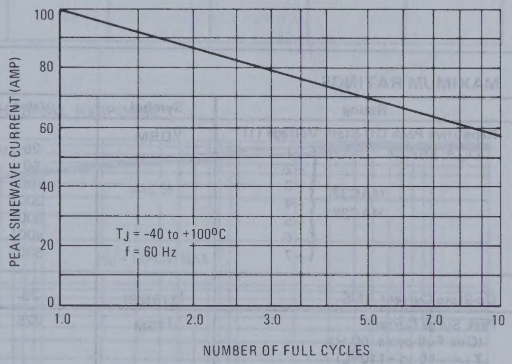
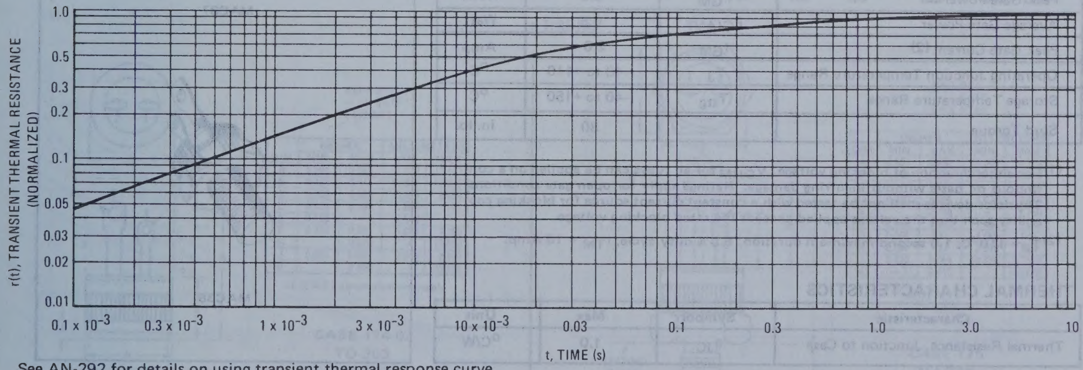


FIGURE 10 – THERMAL RESPONSE



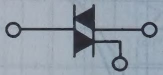
See AN-292 for details on using transient thermal response curve.

MAC37-1 thru MAC37-7 (SILICON)
MAC38-1 thru MAC38-7

SILICON BIDIRECTIONAL THYRISTORS

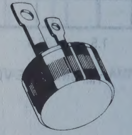
. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

- Glass Passivated and Center Gate Fire
- 25 Amperes RMS @ $T_C = 67^oC$
- Isolated Stud Available

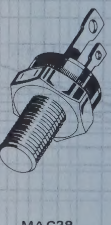


TRIAC
(THYRISTORS)

25 AMPERES RMS
25 thru 500 VOLTS



MAC37



MAC38

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (1) ($T_J = 110^oC$) MAC37, MAC38 –1 –2 –3 –4 –5 –6 –7	V_{DRM}	 25 50 100 200 300 400 500	Volts
On-State Current RMS	$I_{T(RMS)}$	25	Amp
Peak Surge Current (One Full cycle, 60 Hz, $T_J = -40$ to $+110^oC$)	I_{TSM}	225	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+110^oC$, t = 1.0 to 8.3 ms)	I^2t	210	A^2s
Peak Gate Power (2)	P_{GM}	5.0	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current (2)	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	–40 to +110	°C
Storage Temperature Range	T_{stg}	–40 to +150	°C
Stud Torque	–	30	in. lb.

(1) For either direction of blocking voltage. V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) $T_J = 110^oC$, 1.0 second maximum duration; 5.0% duty cycle, $I_{TM} = 10$ Amp.

THERMAL CHARACTERISTICS

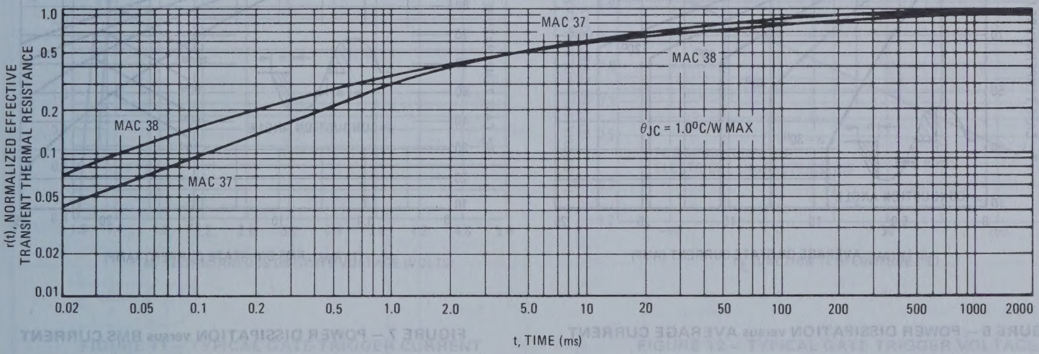
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

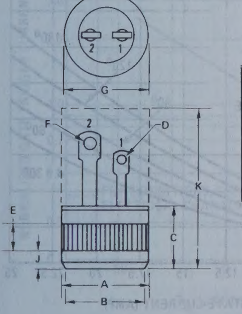
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C	I_{DRM}	–	–	2.0	mA
On-State Voltage (Either Direction) I_{TM} = 35 A Peak	V_{TM}	–	1.4	1.9	Volts
Gate Trigger Current, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms MT2(+)G(+); MT2(–)G(–)	I_{GT}	–	20	75	mA mA
Gate Trigger Voltage, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms MT2(+)G(+); MT2(–)G(–)	V_{GT}	–	1.0	3.0	Volts
Gate Trigger Voltage, Continuous dc – MT2(+) G(+); MT2(–) G(–) Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C	V_{GD}	0.2	–	–	Volt
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 150 mA	I_H	–	10	75	mA
Turn-On Time I_{TM} = 25 Adc, I_{GT} = 200 mA	t_{on}	–	1.0	–	μs
Critical Forward Voltage Application Rate (Exponential Rise of Voltage) @ V_{DRM}, T_J = 110°C, Gate Open	dv/dt	–	100	–	V/μs

(1) All voltage polarity reference to main terminal 1.

FIGURE 1 – MAXIMUM THERMAL RESPONSE



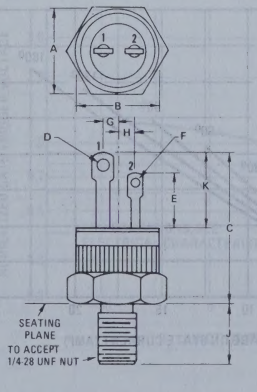


PIN 1. MT1
2. GATE
CASE MT2

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.501	0.505	12.726	12.827
B	0.465	0.475	11.811	12.065
C	0.330	0.380	8.390	9.650
D	0.035	0.068	0.890	1.720
E	0.100	–	2.540	–
F	0.065	0.090	1.660	2.280
G	–	0.510	–	12.950
J	0.080	0.097	2.040	2.460
K	–	0.800	–	20.320

All JEDEC dimensions and notes apply

CASE 174-02
TO-203
MAC37



PIN 1. MT1
2. GATE
CASE MT2

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.551	0.559	14.000	14.200
B	0.501	0.505	12.730	12.830
C	–	0.950	–	74.130
D	0.080	0.095	2.030	2.410
E	–	0.305	–	7.750
F	0.055	0.065	1.400	1.650
G	0.065	REF	1.650	REF
H	0.090	REF	2.290	REF
J	0.420	0.455	10.670	11.560
K	–	0.415	–	10.540

CASE 175
MAC38

FIGURE 2 – AVERAGE CURRENT DERATING

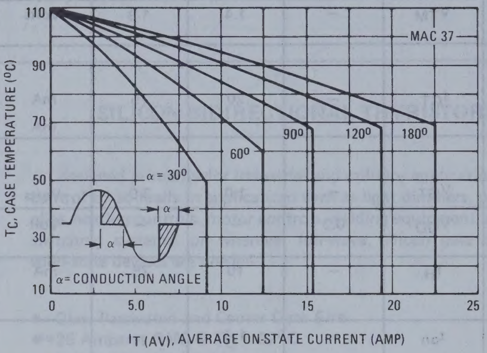


FIGURE 3 – RMS CURRENT DERATING

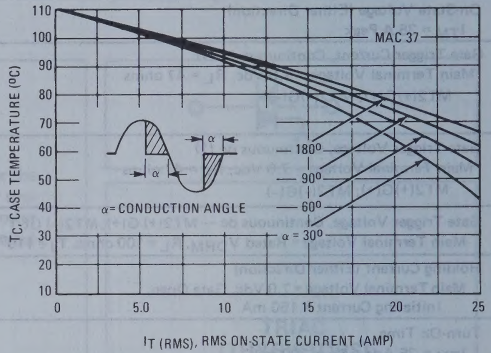


FIGURE 4 – AVERAGE CURRENT DERATING

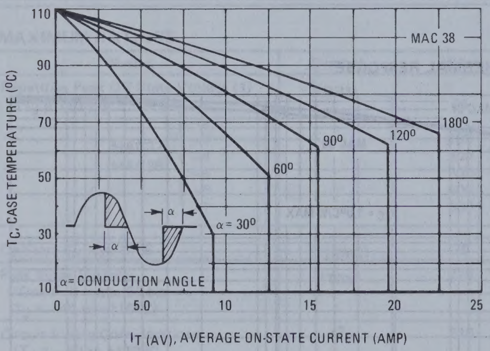


FIGURE 5 – RMS CURRENT DERATING

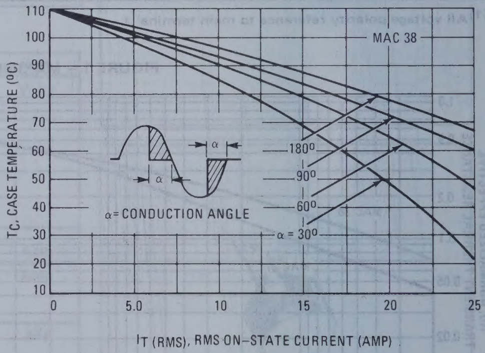


FIGURE 6 – POWER DISSIPATION versus AVERAGE CURRENT

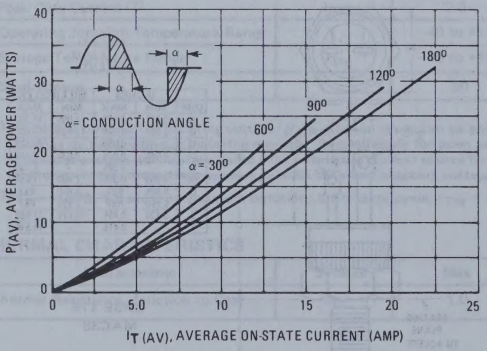


FIGURE 7 – POWER DISSIPATION versus RMS CURRENT

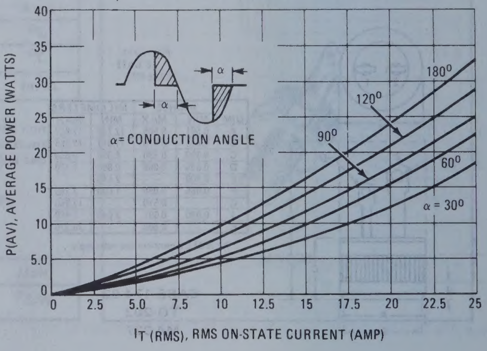


FIGURE 8 – MAXIMUM ON-STATE CHARACTERISTICS

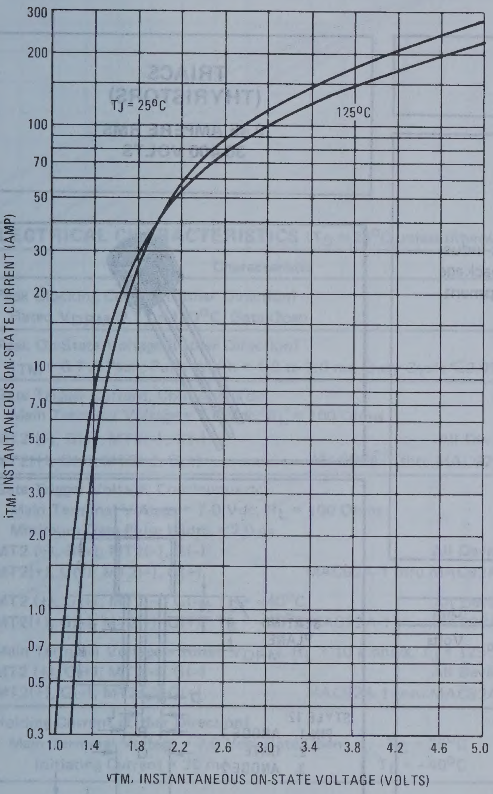


FIGURE 9 – MAXIMUM MULTI-CYCLE SURGE RATING

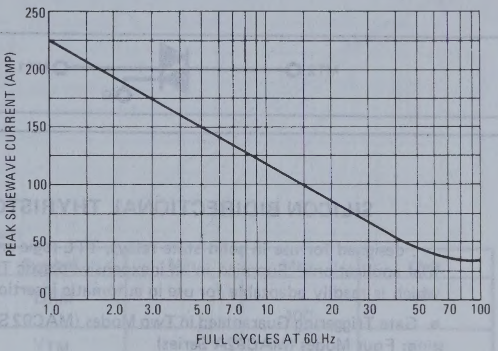


FIGURE 10 – TYPICAL HOLDING CURRENT

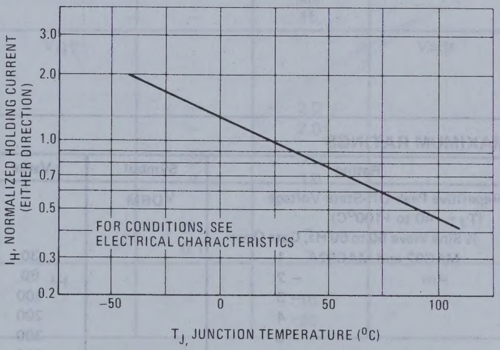


FIGURE 11 – TYPICAL GATE TRIGGER CURRENT

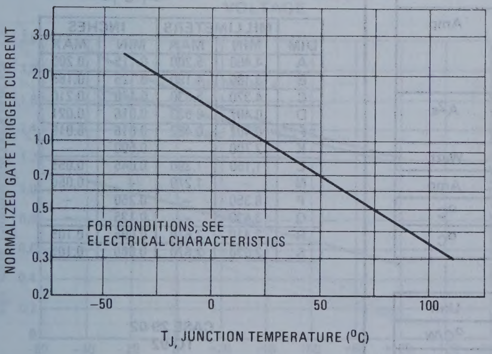
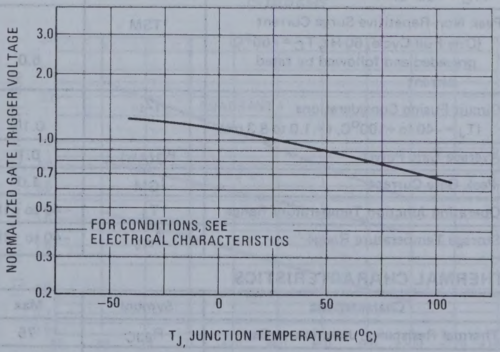
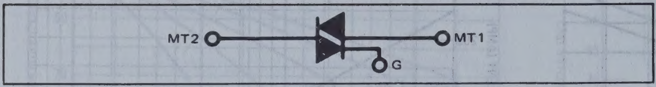


FIGURE 12 – TYPICAL GATE TRIGGER VOLTAGE



MAC92-1 thru MAC92-6 (SILICON)
MAC92A-1 thru MAC92A-6



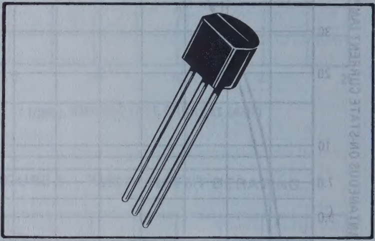
TRIACS (THYRISTORS)

0.45 AMPERE RMS
30-400 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed for use in solid state relays, TTL logic and light industrial applications. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Gate Triggering Guaranteed in Two Modes (MAC92 Series) or Four Modes (MAC92A Series)
- One-Piece, Injection-Molded Unibloc Package

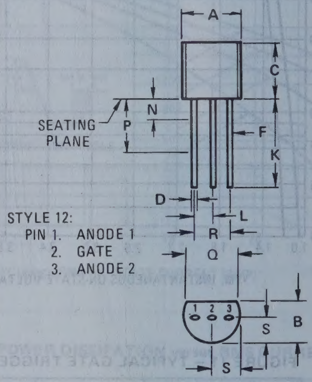


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = -40 to +100°C) ½ Sine Wave 50 to 60 Hz, Gate Open	V_{DRM}		Volts
MAC92 and MAC92A — 1		30	
— 2		60	
— 3		100	
— 4		200	
— 5		300	
— 6		400	
On-State RMS Current Full Cycle Sine Wave 50 to 60 Hz, (T_C = +60°C)	$I_{T(RMS)}$	0.45	Amp
Peak Non-Repetitive Surge Current (One Full Cycle, 60 Hz, T_C = +60°C) preceded and followed by rated current	I_{TSM}	6.0	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Average Gate Power	$P_{G(AV)}$	0.1	Watt
Peak Gate Current	I_{GM}	1.0	Amp
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W



STYLE 12:
PIN 1. ANODE 1
2. GATE
3. ANODE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ $T_J = 100^oC$, Gate Open		I_{DRM}	—	100	μA
Peak On-State Voltage (Either Direction) $I_{TM} = 0.7$ A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ⩽ 2.0%		V_{TM}	—	1.7	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 7.0 Vdc, $R_L = 100$ Ohms		I_{GT}			mA
MT2 (+), G(+); MT2(−), G(−)	All Devices		—	5.0	
MT2(+), G(−); MT2(−), G(+)	MAC92A-1 thru MAC92A-6		—	15	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 7.0 Vdc, $R_L = 100$ Ohms Minimum Gate Pulse Width = 2.0 μs		V_{GT}			Volts
MT2 (+), G(+); MT2(−), G(−)	All Devices		—	2.0	
MT2(+), G(−); MT2(−), G(+)	MAC92A-1 thru MAC92A-6		—	2.0	
MT2 (+), G(+); MT2(−), G(−), $T_C = -40^oC$	All Devices		—	3.0	
MT2(+), G(−); MT2(−), G(+) $T_C = -40^oC$	MAC92A-1 thru MAC92A-6		—	3.0	
Main Terminal Voltage = Rated V_{DRM}, $R_L = 10$ k ohms, $T_J = 125^oC$					
MT2 (+), G(+); MT2(−), G(−)	All Devices		0.1	—	
MT2(+), G(−); MT2(−), G(+)	MAC92A-1 thru MAC92A-6		0.1	—	
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open; Initiating Current = 20 mA	$T_C = 25^oC$ $T_C = -40^oC$	I_H	— —	10 20	mA

FIGURE 1 — TYPICAL GATE TRIGGER VOLTAGE

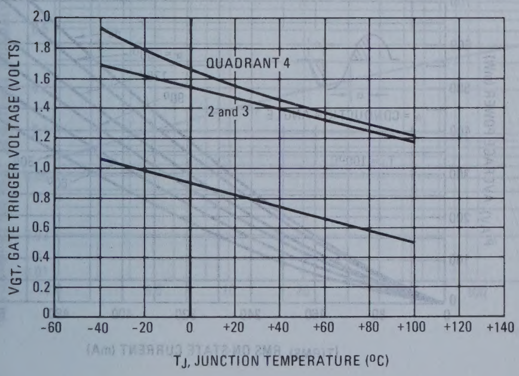


FIGURE 2 — TYPICAL GATE TRIGGER CURRENT

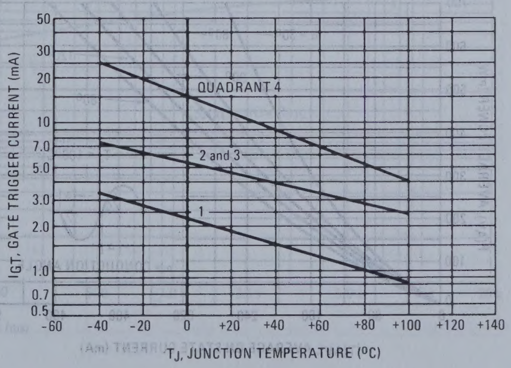


FIGURE 3 – AVERAGE CURRENT DERATING (REFERENCE: CASE TEMPERATURE)

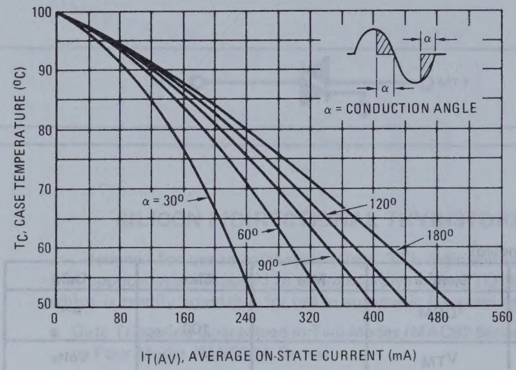


FIGURE 4 – RMS CURRENT DERATING (REFERENCE: CASE TEMPERATURE)

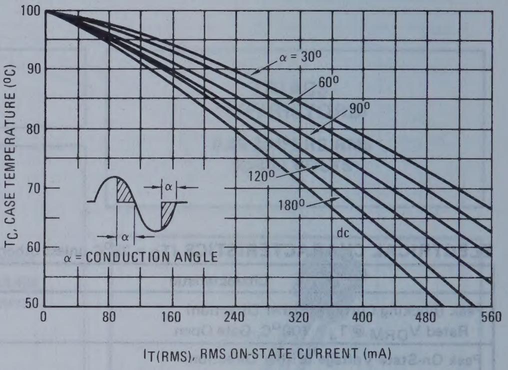


FIGURE 5 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE)

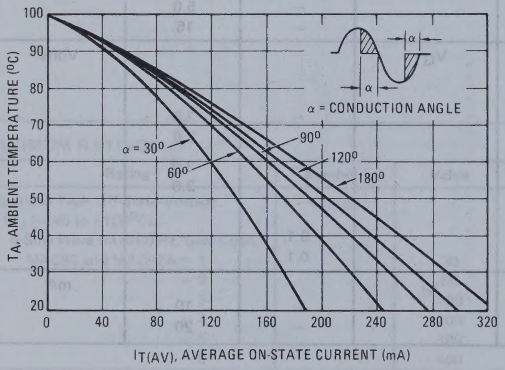


FIGURE 6 – RMS CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE)

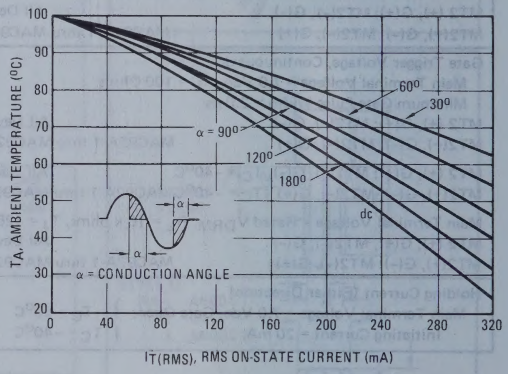


FIGURE 7 – ON-STATE POWER DISSIPATION

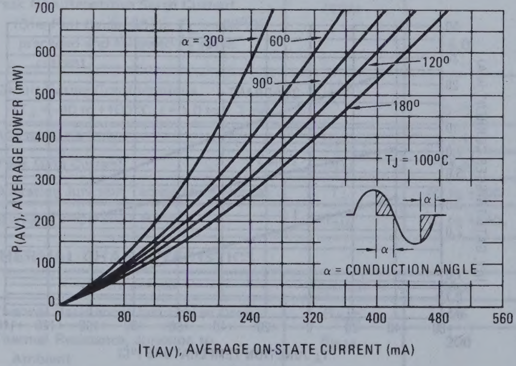


FIGURE 8 – ON-STATE POWER DISSIPATION

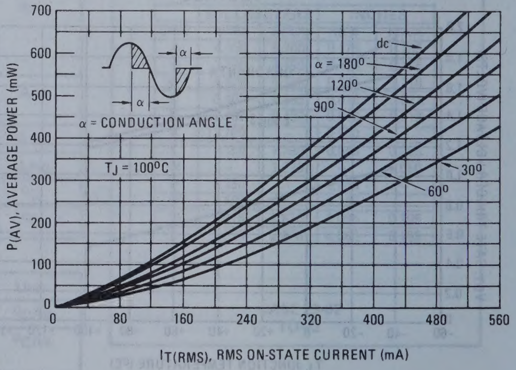


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

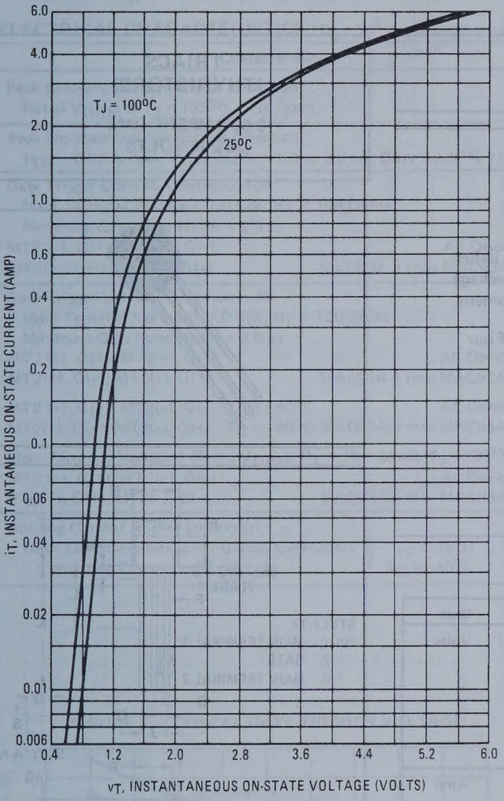


FIGURE 10 – TYPICAL HOLDING CURRENT

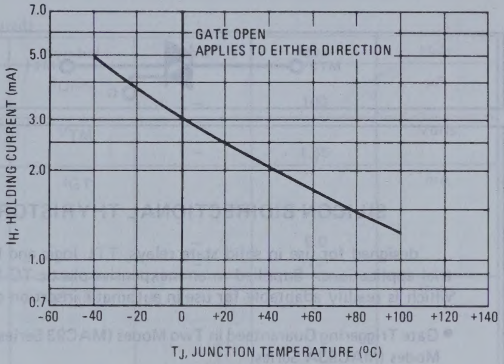


FIGURE 11 – MAXIMUM ALLOWABLE SURGE CURRENT

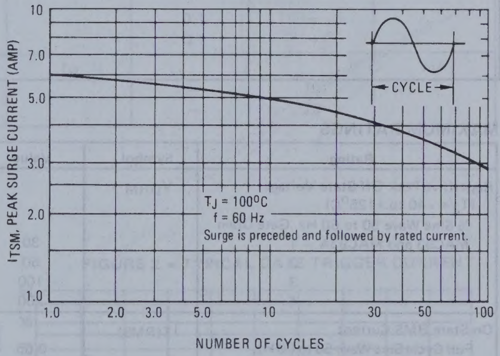
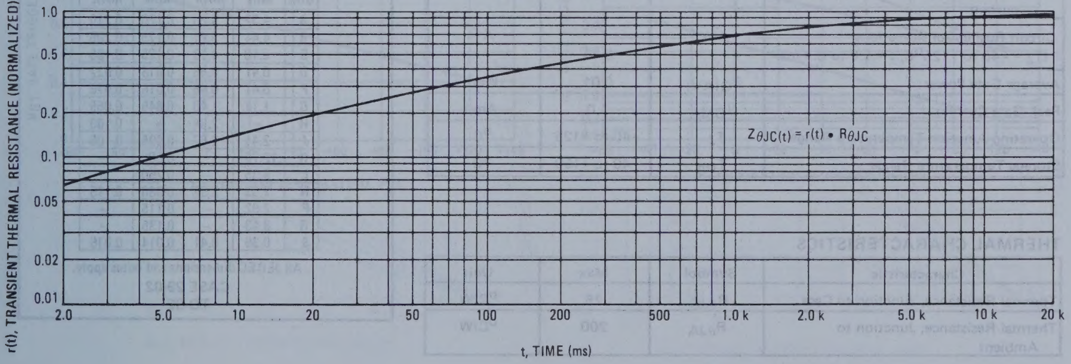
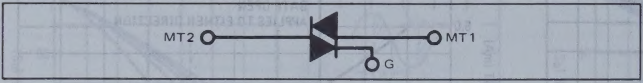


FIGURE 12 – THERMAL RESPONSE



MAC93-1 thru MAC93-4 (SILICON)
MAC93A-1 thru MAC93A-4



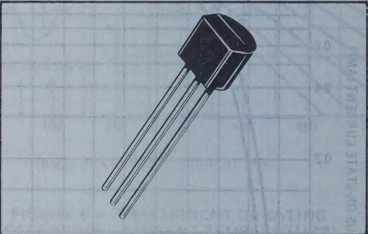
TRIACS (THYRISTORS)

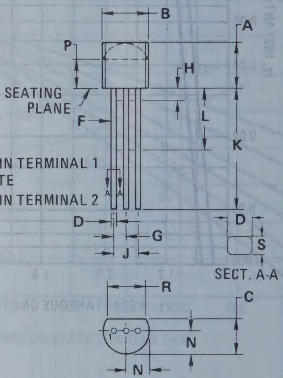
0.65 AMPERE RMS
30-200 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed for use in solid state relays, TTL logic and light industrial applications. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Gate Triggering Guaranteed in Two Modes (MAC93 Series) or Four Modes (MAC93A Series)
- One-Piece, Injection-Molded Unibloc Package





STYLE 12:
PIN 1. MAIN TERMINAL 1
2. GATE
3. MAIN TERMINAL 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.14	1.40	0.045	0.055
H	–	2.54	–	0.100
J	2.41	2.67	0.095	0.105
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.92	0.080	0.115
P	2.92	–	0.115	–
R	3.43	–	0.135	–
S	0.36	0.41	0.014	0.016

All JEDEC dimensions and notes apply.

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = −40 to +125°C) ½ Sine Wave 50 to 60 Hz, Gate Open MAC93 and MAC93A — 1	V_{DRM}	30	Volts
2		60	
3		100	
4		200	
On-State RMS Current Full Cycle Sine Wave 50 to 60 Hz, (T_C = +60°C)	$I_{T(RMS)}$	0.65	Amp
Peak Non-Repetitive Surge Current (One Full Cycle, 60 Hz, T_C = +60°C) preceded and followed by rated current	I_{TSM}	6.0	Amp
Circuit Fusing Considerations (T_J = −40 to +125°C, t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Average Gate Power	$P_{G(AV)}$	0.01	Watt
Peak Gate Current	I_{GM}	1.0	Amp
Operating Junction Temperature Range	T_J	−40 to +125	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 125°C, Gate Open	I_{DRM}	—	100	μA
Peak On-State Voltage (Either Direction) I_{TM} = 0.92 A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ⩽ 2.0%	V_{TM}	—	1.85	Volts
Gate Trigger Current, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	I_{GT}			mA
MT2 (+), G(+); MT2(-), G(-) — All Devices		—	5.0	
MT2(+), G(-); MT2(-), G(+) — MAC93A-1 thru MAC93A-4		—	12	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 μs	V_{GT}			Volts
MT2 (+), G(+); MT2(-), G(-) — All Devices		—	2.0	
MT2(+), G(-); MT2(-), G(+) — MAC93A-1 thru MAC93A-4		—	2.0	
MT2 (+), G(+); MT2(-), G(-) T_C = -40°C — All Devices		—	2.5	
MT2(+), G(-); MT2(-), G(+) T_C = -40°C — MAC93A-1 thru MAC93A-4		—	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 125°C				
MT2 (+), G(+); MT2(-), G(-) — All Devices		0.1	—	
MT2(+), G(+); MT2(-), G(-) — MAC93A-1 thru MAC93A-4		0.1	—	
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 20 mA } T_C = 25°C	I_H	—	10	mA
} T_C = -40°C		—	20	

FIGURE 1 — TYPICAL GATE TRIGGER VOLTAGE

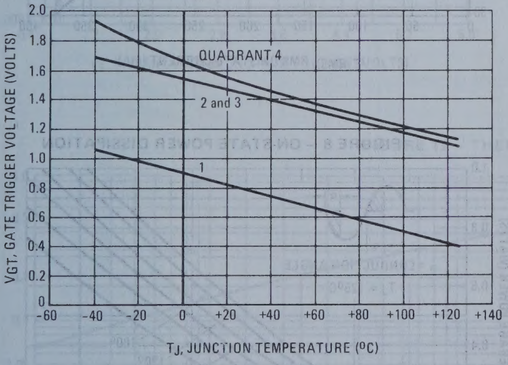


FIGURE 2 — TYPICAL GATE TRIGGER CURRENT

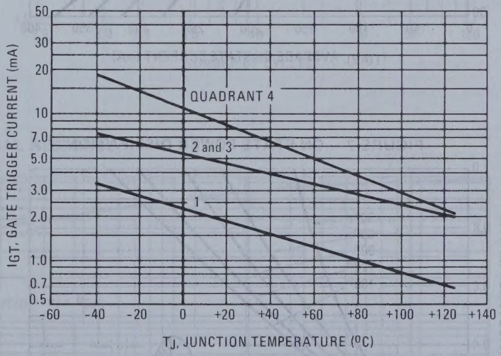


FIGURE 3 – AVERAGE CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

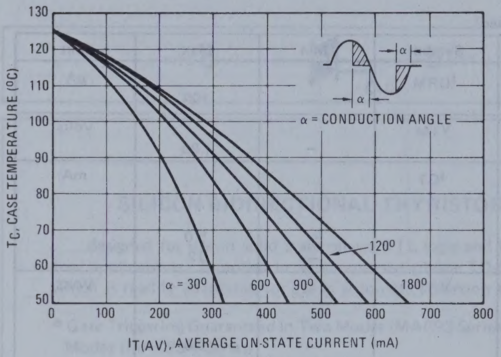


FIGURE 4 – RMS CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

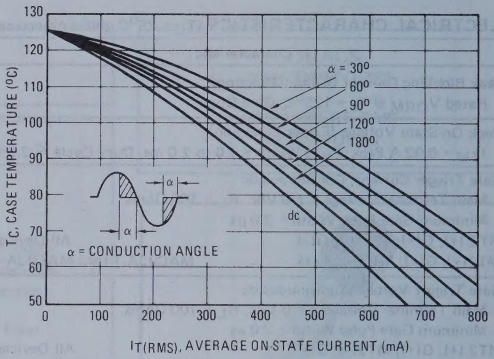


FIGURE 5 – AVERAGE CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

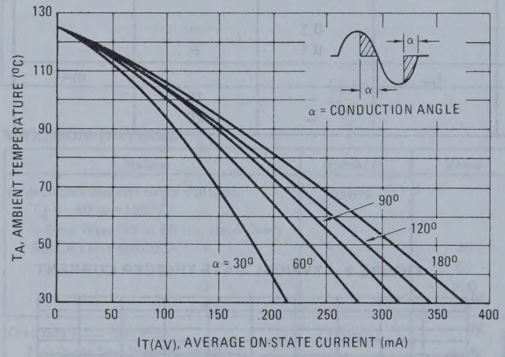


FIGURE 6 – RMS CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

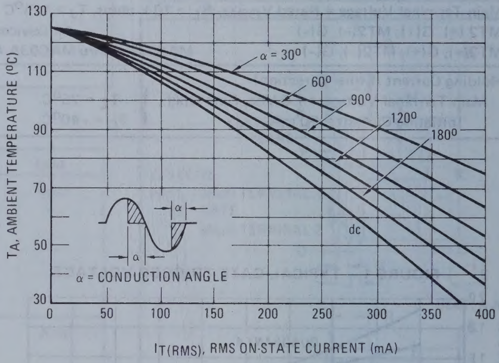


FIGURE 7 – ON-STATE POWER DISSIPATION

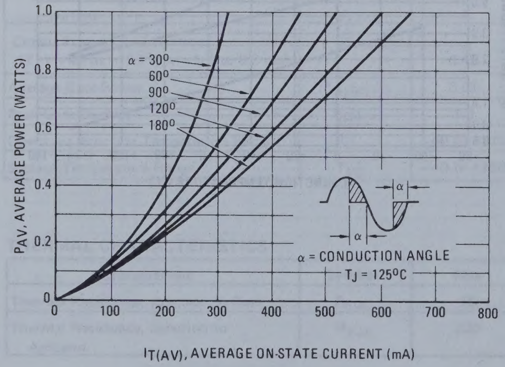
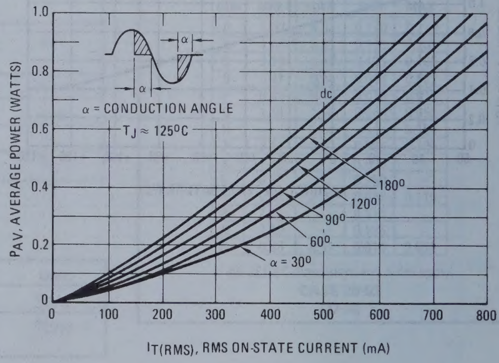


FIGURE 8 – ON-STATE POWER DISSIPATION



MAC93-1 thru MAC93-4,MAC93A-1 thru MAC93A-4 (continued)

FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

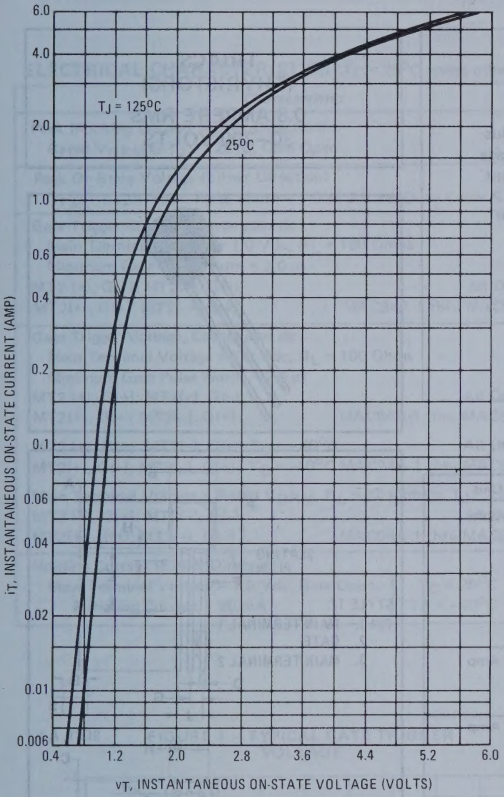


FIGURE 10 – TYPICAL HOLDING CURRENT

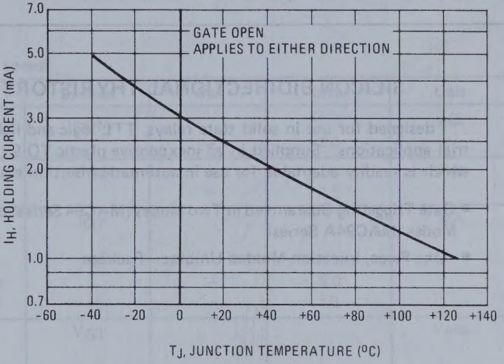


FIGURE 11 – MAXIMUM NON-REPETITIVE SURGE CURRENT

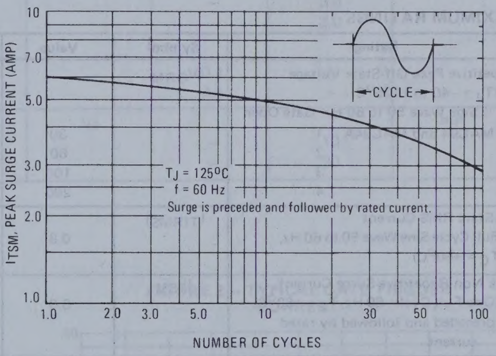
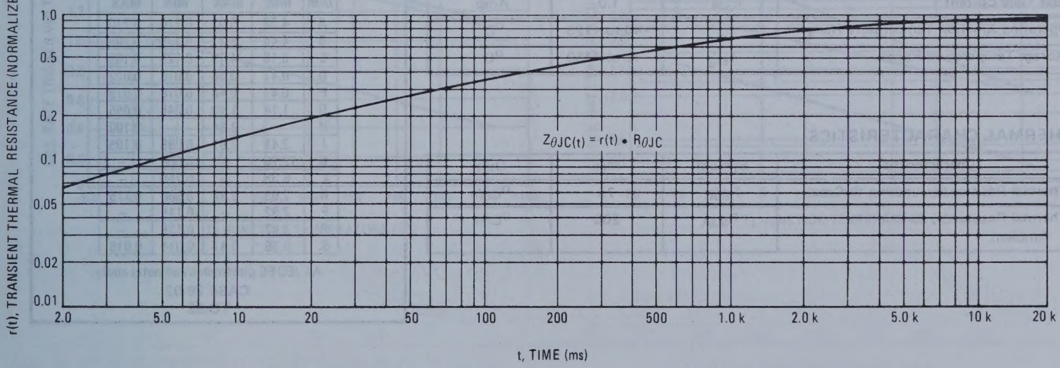


FIGURE 12 – THERMAL RESPONSE



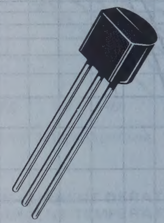
MAC94-1 thru MAC94-4 (SILICON)
MAC94A-1 thru MAC94A-4

SILICON BIDIRECTIONAL THYRISTORS

. . . designed for use in solid state relays, TTL logic and light industrial applications. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Gate Triggering Guaranteed in Two Modes (MAC94 Series) or Four Modes (MAC94A Series)
- One-Piece, Injection-Molded Unibloc Package

TRIACS
(THYRISTORS)
0.8 AMPERE RMS
30–200 VOLTS

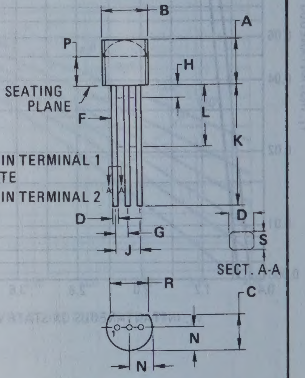


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = −40 to +125°C) ½ Sine Wave 50 to 60 Hz, Gate Open MAC94 and MAC94A – 1 2 3 4	V_{DRM}	30 60 100 200	Volts
On-State RMS Current Full Cycle Sine Wave 50 to 60 Hz, (T_C = +60°C)	$I_{T(RMS)}$	0.8	Amp
Peak Non-Repetitive Surge Current (One Full Cycle, 60 Hz, T_C = +60°C) preceded and followed by rated current	I_{TSM}	6.0	Amp
Circuit Fusing Considerations (T_J = −40 to +125°C, t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Average Gate Power	$P_{G(AV)}$	0.01	Watt
Peak Gate Current	I_{GM}	1.0	Amp
Operating Junction Temperature Range	T_J	−40 to +125	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	75	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W



STYLE 12:
PIN 1. MAIN TERMINAL 1
2. GATE
3. MAIN TERMINAL 2

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.44	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.56	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.14	1.40	0.045	0.055
H	–	2.54	–	0.100
J	2.41	2.67	0.095	0.105
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.92	0.080	0.115
P	2.92	–	0.115	–
R	3.43	–	0.135	–
S	0.36	0.41	0.014	0.016

All JEDEC dimensions and notes apply.
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Peak Blocking Current (Either Direction)	I_{DRM}			mA
Rated V_{DRM} @ T_J = 125°C, Gate Open		–	2.0	
Peak On-State Voltage (Either Direction)	V_{TM}			Volts
I_{TM} = 1.12A Peak; Pulse Width = 1.0 to 2.0 ms, Duty Cycle ⩽ 2.0%		–	1.5	
Gate Trigger Current, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 µs	I_{GT}			mA
MT2 (+), G(+); MT2(–), G(–) All Devices		–	5.0	
MT2(+), G(–); MT2(–), G(+) MAC94A-1 thru MAC94A-4		–	10	
Gate Trigger Voltage, Continuous dc Main Terminal Voltage = 7.0 Vdc, R_L = 100 Ohms Minimum Gate Pulse Width = 2.0 µs	V_{GT}			Volts
MT2 (+), G(+); MT2(–), G(–) All Devices		–	2.0	
MT2(+), G(–); MT2(–), G(+) MAC94A-1 thru MAC94A-4		–	2.0	
MT2 (+), G(+); MT2(–), G(–) T_C = –40°C All Devices		–	3.0	
MT2(+), G(–); MT2(–), G(+) T_C = –40°C MAC94A-1 thru MAC94A-4		–	3.0	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 125°C				
MT2 (+), G(+); MT2(–), G(–) All Devices		0.1	–	
MT2(+), G(+); MT2(–), G(–) MAC94A-1 thru MAC94A-4		0.1	–	
Holding Current (Either Direction)	I_H			mA
Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 20 mA } T_C = 25°C		–	10	
T_C = –40°C		–	20	

FIGURE 1 – TYPICAL GATE TRIGGER VOLTAGE

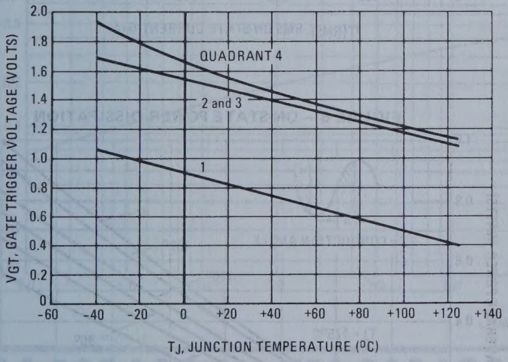


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

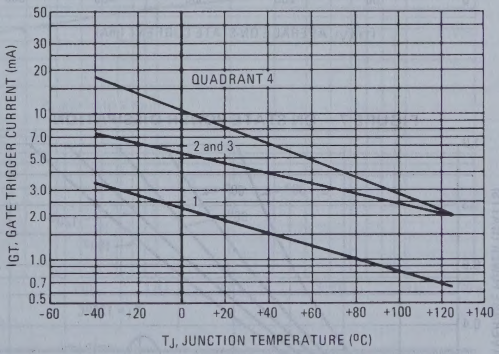


FIGURE 3 – AVERAGE CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

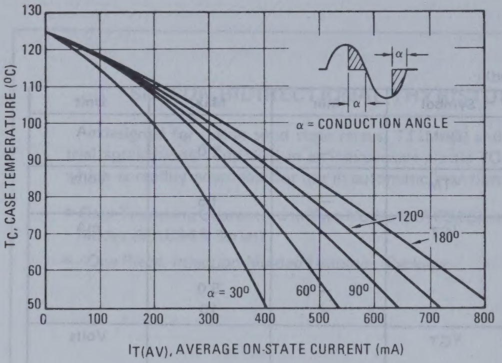


FIGURE 4 – RMS CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

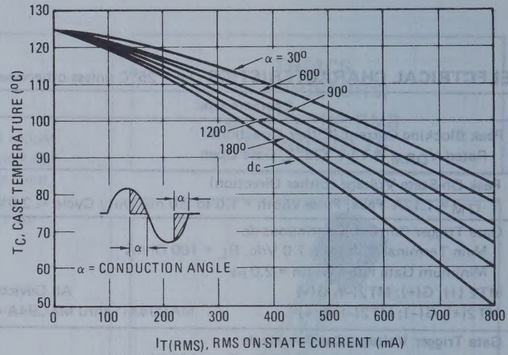


FIGURE 5 – AVERAGE CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

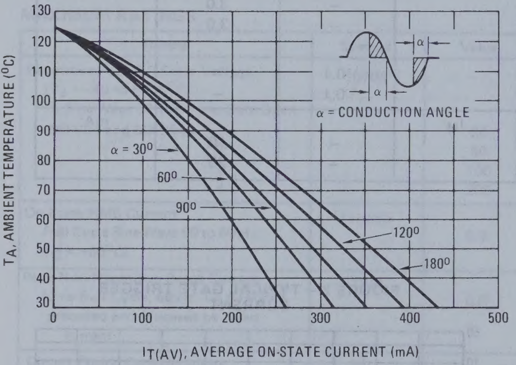


FIGURE 6 – RMS CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

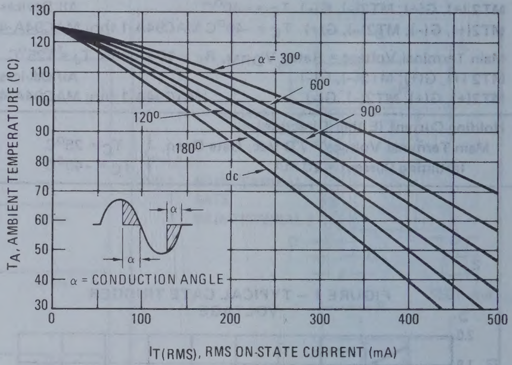


FIGURE 7 – ON-STATE POWER DISSIPATION

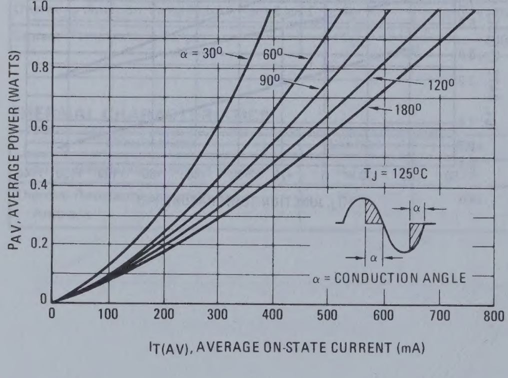


FIGURE 8 – ON-STATE POWER DISSIPATION

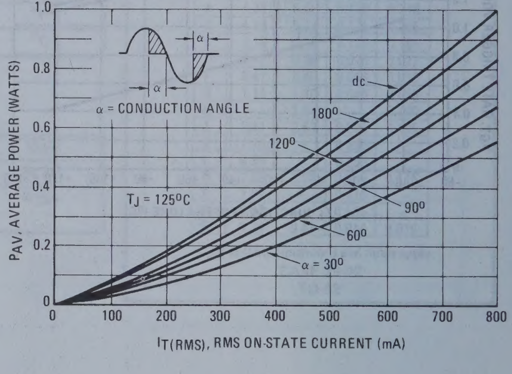


FIGURE 9 — MAXIMUM ON-STATE CHARACTERISTICS

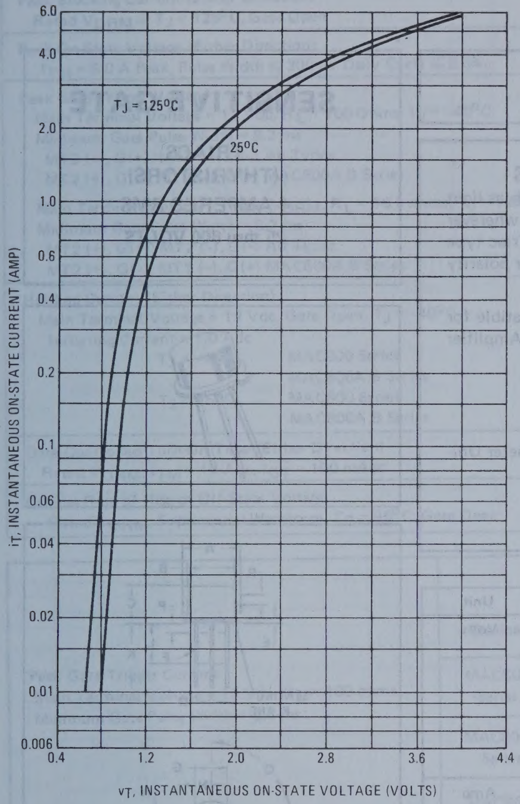


FIGURE 10 — TYPICAL HOLDING CURRENT

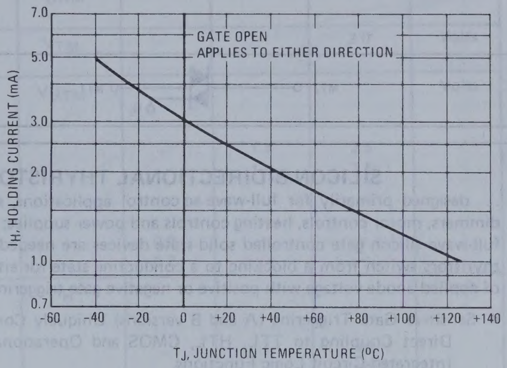


FIGURE 11 — MAXIMUM NON-REPETITIVE SURGE CURRENT

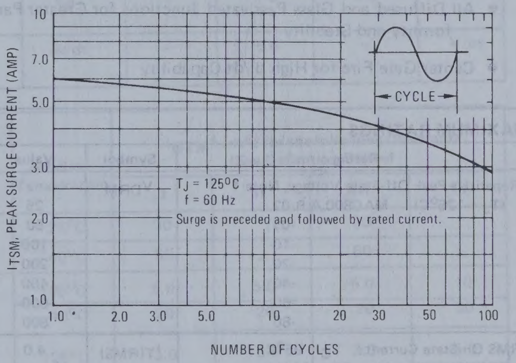
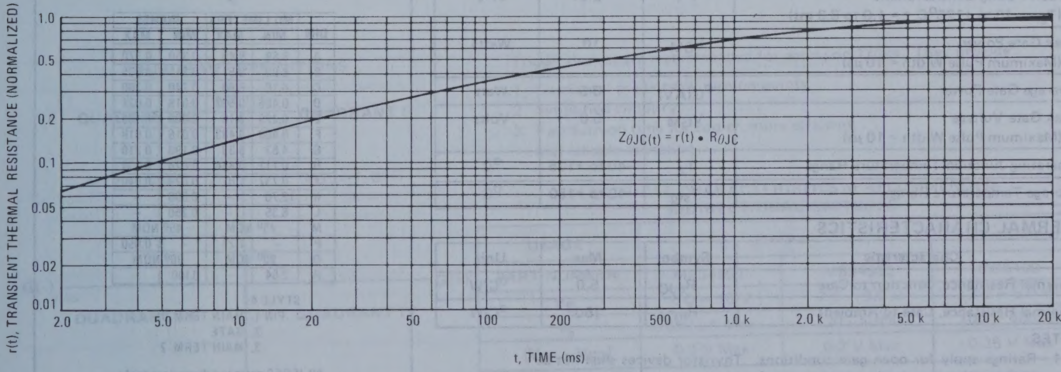


FIGURE 12 — THERMAL RESPONSE



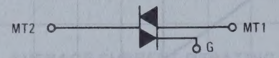
MAC40688 thru MAC40690

For Specifications, See 2N5441 Data, Volume II.

MAC40797, MAC40798

For Specifications, See 2N5571 Data, Volume II.

MAC800, A, B (SILICON)
Series



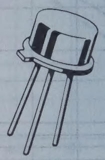
SENSITIVE GATE

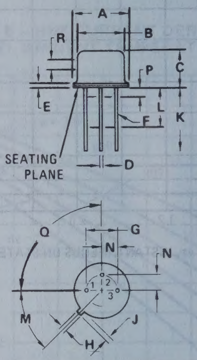
TRIACS
(THYRISTORS)
4 AMPERES RMS
25 thru 800 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for full-wave ac control applications, such as light dimmers, motor controls, heating controls and power supplies; or wherever full-wave silicon gate controlled solid-state devices are needed. Triac type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.

- Sensitive Gate Triggering (A and B versions) Uniquely Compatible for Direct Coupling to TTL, HTL, CMOS and Operational Amplifier Integrated Circuit Logic Functions.
- Gate Triggering 2 Quadrants – MAC800 Series
  4 Quadrants – MAC800A,B Series
- Blocking Voltages to 800 Volts
- All Diffused and Glass Passivated Junctions for Greater Parameter Uniformity and Stability
- Center Gate Fire for High di/dt Capability





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

STYLE 4:
PIN 1. MAIN TERM. 1
2. GATE
3. MAIN TERM. 2

All JEDEC notes and dimensions apply.

CASE 79-02
TO-39

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage, Note 1 (T_J = 125°C) MAC800,A,B-02	V_{DRM}	25	Volts
-05		50	
-10		100	
-20		200	
-40		400	
-60		600	
-80		800	
RMS On-State Current T_C = 95°C (Full Cycle Sine Wave 50 to 60 Hz)	$I_{T(RMS)}$	4.0	Amp
Peak Non-Repetitive Surge Current (One Full cycle, 60 Hz, T_J = -40 to +125°C)	I_{TSM}	40	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.0 to 8.3 ms)	I^2t	6.5	A^2s
Peak Gate Power (Maximum Pulse Width = 10 μs)	P_{GM}	10	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Voltage (Maximum Pulse Width = 10 μs)	V_{GM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	°C/W
Thermal Resistance, Case to Ambient	$R_{\theta CA}$	150	°C/W

NOTES:

1. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.
2. For soldering purposes, soldering temperatures shall not exceed +230°C for 10 seconds.

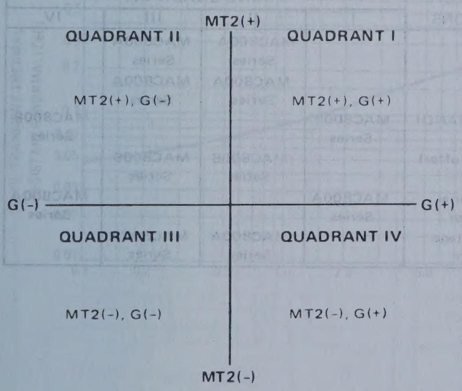
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 125°C, Gate Open	I_{DRM}	—	0.5	2.0	mA
Peak On-State Voltage (Either Direction) I_{TM} = 6.0 A Peak, Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.	V_{TM}	—	—	2.0	Volts
Peak Gate Trigger Voltage Main Terminal Voltage = 12 Vdc, R_L = 100 Ohms, T_J = -40°C Minimum Gate Pulse Width = 8.3 ms	V_{GTM}				Volts
MT2 (+), G(+); MT2 (-), G(-) All Types		—	1.4	2.5	
MT2 (+), G(-); MT2 (-), G(+) MAC800A,B Series		—	1.4	2.5	
Main Terminal Voltage = Rated V_{DRM}, R_L = 10 k ohms, T_J = 125°C Minimum Gate Pulse Width = 8.3 ms					
MT2 (+), G(+); MT2 (-), G(-) All Types		0.2	—	—	
MT2 (+), G(-); MT2 (-), G(+) MAC800A,B Series		0.2	—	—	
Holding Current (Either Direction) Main Terminal Voltage = 12 Vdc, Gate Open, T_J = -40°C Initiating Current = 1.0 Adc	I_H				mA
T_J = -40°C MAC800 Series		—	—	70	
MAC800A,B Series		—	—	30	
T_J = 25°C MAC800 Series		—	—	30	
MAC800A,B Series		—	—	15	
Gate Controlled Turn-On Time (Either Direction) Rated V_{DRM}, I_{TM} = 14 Adc, I_{GT} = 100 mAdc	t_{gt}	—	1.0	2.0	μs
Critical Rate of Rise of Off-State Voltage Rated V_{DRM}, Exponential Waveform, T_C = 95°C, Gate Open	dv/dt	—	5.0	—	V/μs

	Device	Junction Temperature	I_{GTM}* (mA) for the following Quadrants (See Definition Below)			
			I	II	III	IV
Peak Gate Trigger Current Main Terminal Voltage = 12 Vdc, R_L = 100 ohms Minimum Gate Pulse Width = 8.3 ms	MAC800 Series	+25°C	30	—	30	—
		-40°C	60	—	60	—
	MAC800A Series	+25°C	5.0	5.0	5.0	10
		-40°C	20	20	20	30
	MAC800B Series	+25°C	3.0	3.0	3.0	5.0
		-40°C	15	15	15	20

*The values listed are Maximum Values.

QUADRANT DEFINITIONS



Trigger devices are recommended for gating on Triacs. They provide

1. Consistent predictable turn-on points.
2. Simplified circuitry.
3. Fast turn-on time for cooler, more efficient and reliable operation.

ELECTRICAL CHARACTERISTICS of RECOMMENDED BIDIRECTIONAL SWITCHES

USAGE	General		Lamp Dimmer
PART NUMBER	MBS4991	MBS4992	MBS100
V_S	6.0 – 10 V	7.5 – 9.0 V	3.0 – 5.0 V
I_S	350 μA Max	120 μA Max	100 – 400 μA
$\|V_{S1} - V_{S2}\|$	0.5 V Max	0.2 V Max	0.35 V Max
Temperature Coefficient	0.02%/°C Typ		0.05%/°C Typ

See AN-526 for Theory and Characteristics of Silicon Bidirectional Switches.

FIGURE 1 – RMS CURRENT DERATING

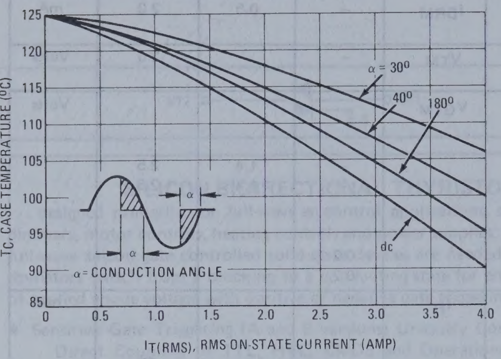


FIGURE 2 – POWER DISSIPATION

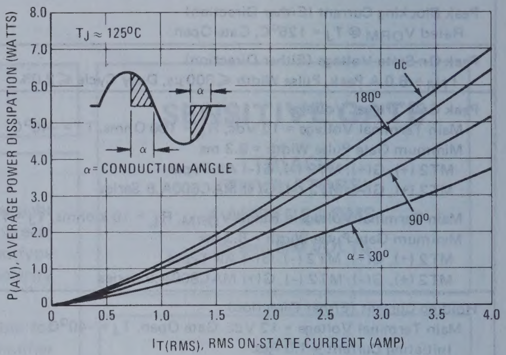


FIGURE 3 – TYPICAL GATE-TRIGGER VOLTAGE

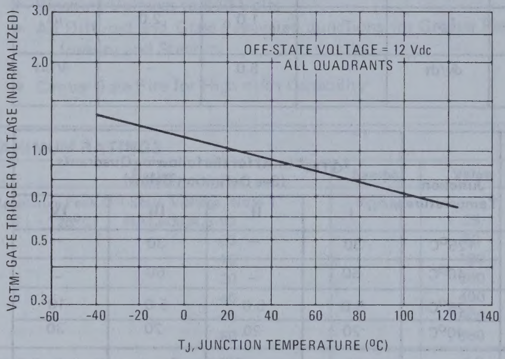
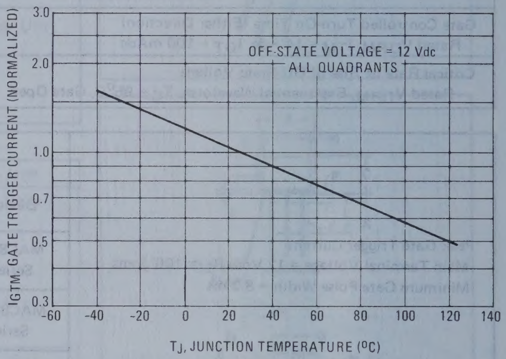
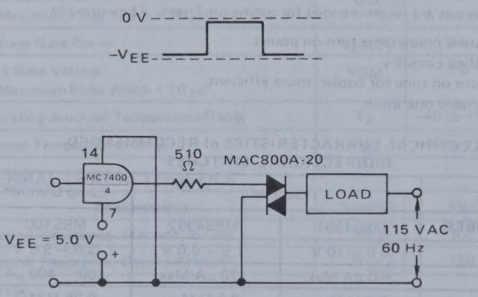


FIGURE 4 – TYPICAL GATE-TRIGGER CURRENT



SAMPLE APPLICATION:
TTL-SENSITIVE GATE 4 AMPERE TRIAC
TRIGGERS IN QUADRANTS II AND III



IC LOGIC FUNCTIONS	FIRING QUADRANT			
	I	II	III	IV
TTL		MAC800A Series	MAC800A Series	
HTL		MAC800A Series	MAC800A Series	
CMOS (NAND)	MAC800B Series			MAC800B Series
CMOS (Buffer)		MAC800B Series	MAC800B Series	
Operational Amplifier	MAC800A Series			MAC800A Series
Zero Voltage Switch		MAC800A Series	MAC800A Series	

FIGURE 5 – MAXIMUM ON-STATE CHARACTERISTICS

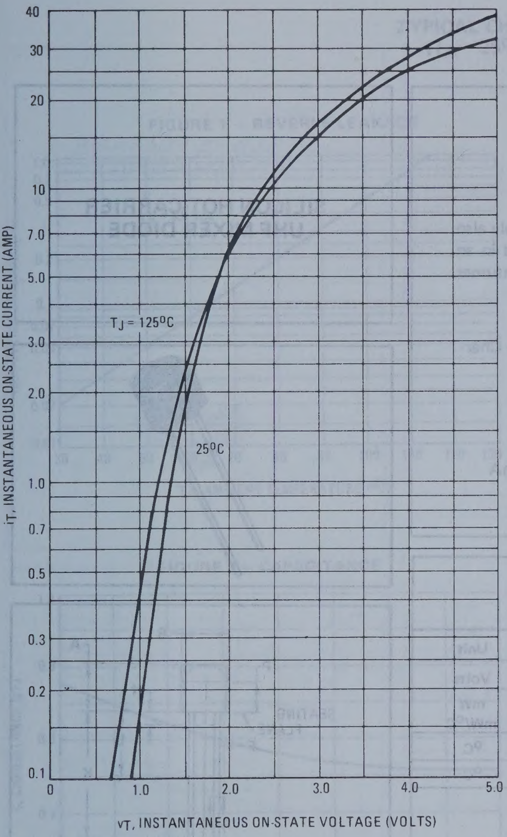


FIGURE 6 – TYPICAL HOLDING CURRENT

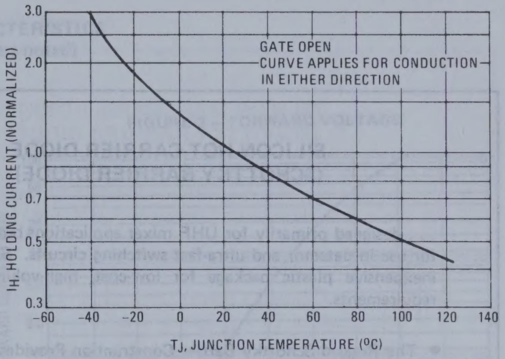


FIGURE 7 – MAXIMUM NON-REPETITIVE SURGE CURRENT

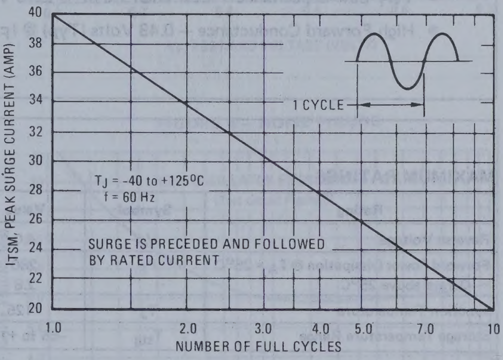
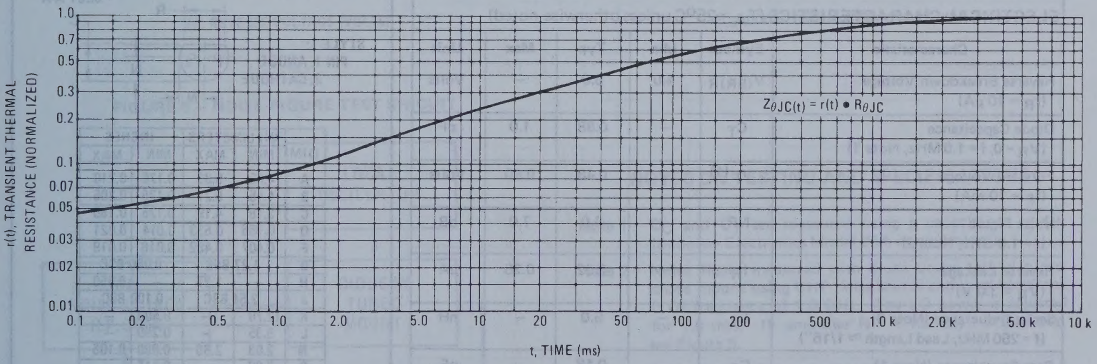


FIGURE 8 – THERMAL RESPONSE



MBD101 (SILICON)

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in an inexpensive plastic package for low-cost, high-volume consumer requirements.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure — 7.0 dB Max @ 1.0 GHz
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- High Forward Conductance — 0.48 Volts (Typ) @ I_F = 10 mA

SILICON HOT-CARRIER UHF MIXER DIODE

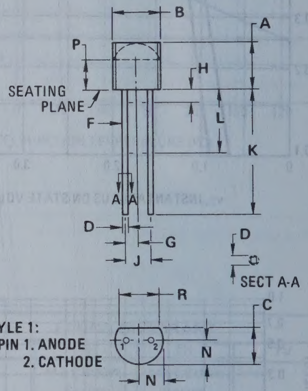
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_F	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µA)	$V_{(BR)R}$	4.0	5.0	–	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	–	0.88	1.0	pF
Forward Voltage (I_F = 10 mA)	$V_F{}^{(1)}$	–	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	–	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	–	0.02	0.25	µA
Series Inductance (Note 3) (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (Note 1) (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.



STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

CASE 182-02

TYPICAL CHARACTERISTICS

(T$_A$ = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

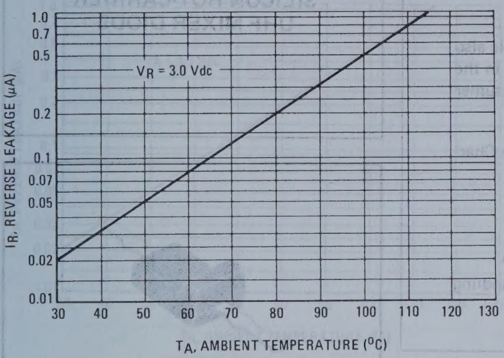


FIGURE 2 – FORWARD VOLTAGE

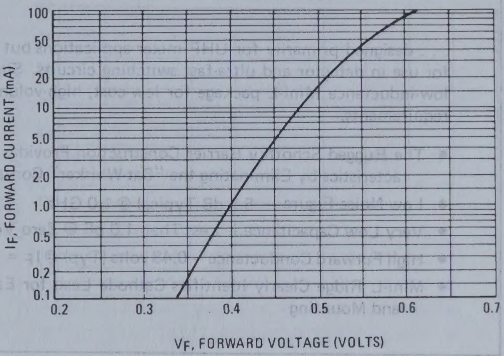


FIGURE 3 – CAPACITANCE

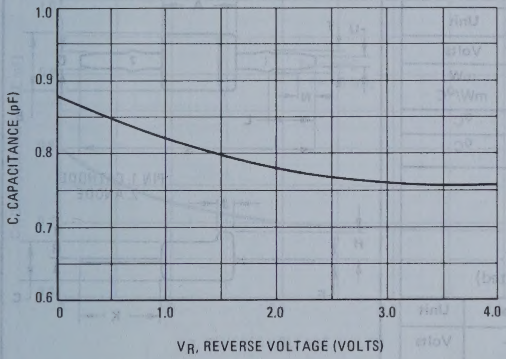


FIGURE 4 – NOISE FIGURE

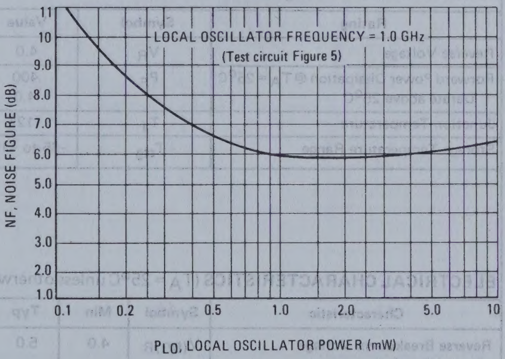
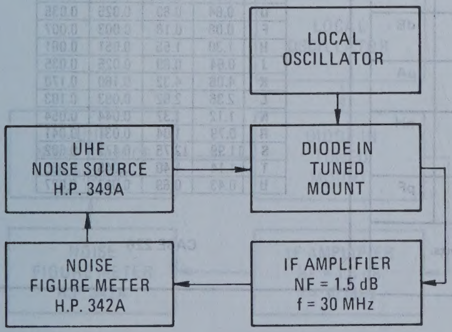


FIGURE 5 – NOISE FIGURE TEST CIRCUIT



LOCAL OSCILLATOR
UHF NOISE SOURCE H.P. 349A
DIODE IN TUNED MOUNT
NOISE FIGURE METER H.P. 342A
IF AMPLIFIER NF = 1.5 dB f = 30 MHz

NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C$_C$ and C$_T$ are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L$_S$ is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBD102 (SILICON)

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in the low-inductance Mini-L package for low-cost, high-volume consumer requirements.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure — 5.5 dB Typical @ 1.0 GHz
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- High Forward Conductance — 0.48 volts (Typ) @ I_F = 10 mA
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

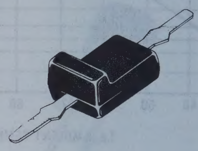
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

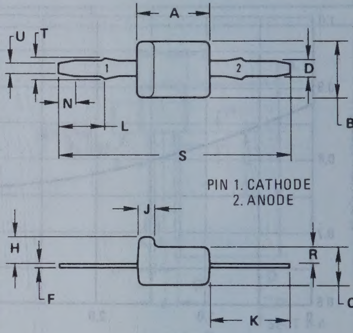
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	—	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	—	0.8	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F(1)	—	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	—	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	—	0.02	0.25	μA
Series Inductance (Note 3) (f = 250 MHz, Measured at Lead Stop ≈ 1/8")	L_S	—	3.0	—	nH
Case Capacitance (Note 1) (f = 1.0 MHz)	C_C	—	0.1	—	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.

SILICON HOT-CARRIER UHF MIXER DIODE





PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

TYPICAL CHARACTERISTICS

(T_A = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

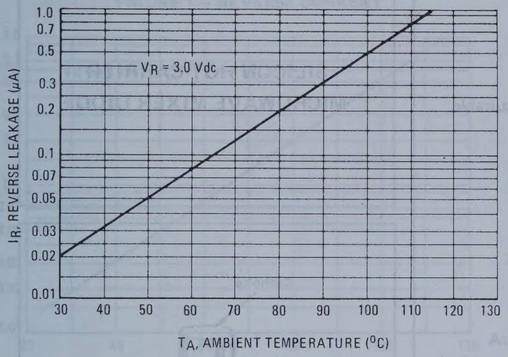


FIGURE 2 – FORWARD VOLTAGE

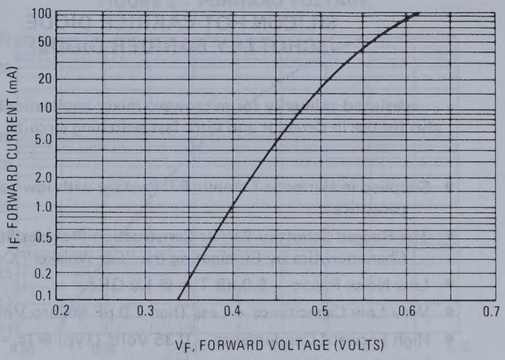


FIGURE 3 – DIODE CAPACITANCE

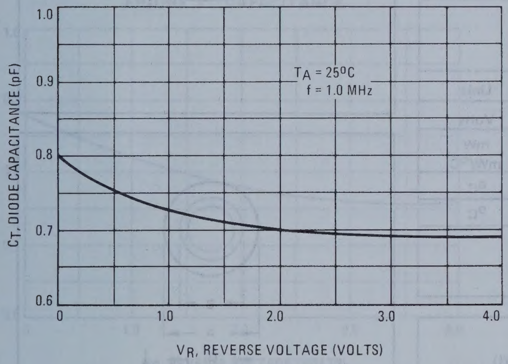


FIGURE 4 – NOISE FIGURE

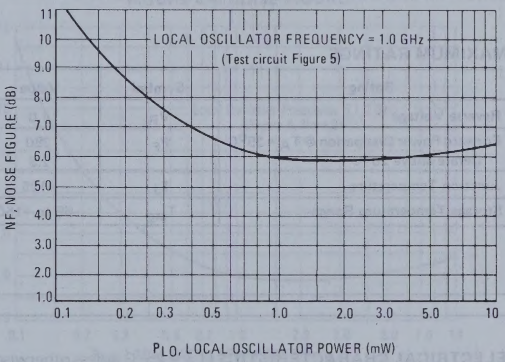
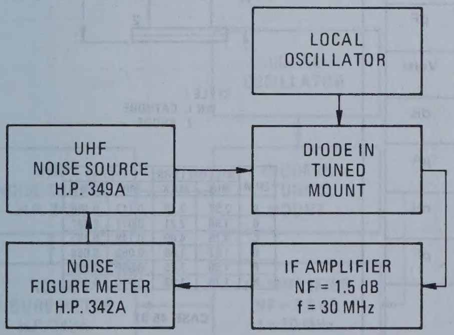


FIGURE 5 – NOISE FIGURE TEST CIRCUIT


LOCAL OSCILLATOR
UHF NOISE SOURCE H.P. 349A
DIODE IN TUNED MOUNT
NOISE FIGURE METER H.P. 342A
IF AMPLIFIER NF = 1.5 dB f = 30 MHz

NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

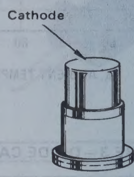
MBD103 (SILICON)

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for microwave mixer applications but suitable also for use in detector and ultra-fast switching circuits.

- Supplied in Hermetic Ceramic Pill Package with low package parasitics
- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure – 6.0 dB Typ @ 1.0 GHz
- Very Low Capacitance – Less Than 1.0 pF @ Zero Volts
- High Forward Conductance – 0.35 Volts (Typ) @ I_F = 100 μA

SILICON HOT-CARRIER MICROWAVE MIXER DIODE

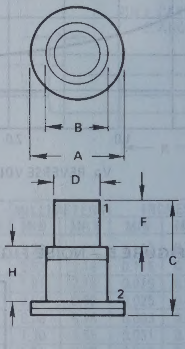


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	–	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	–	0.88	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F	–	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	–	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	–	0.016	0.25	μA
Series Inductance (Note 3) (f = 250 MHz)	L_S	–	0.8	–	nH
Case Capacitance (Note 1) (f = 1.0 MHz)	C_C	–	0.15	–	pF



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.97	3.30	0.117	0.130
B	1.96	2.21	0.077	0.087
C	3.78	4.09	0.149	0.161
D	1.52	1.68	0.060	0.066
F	1.50	1.65	0.059	0.065
H	1.78	1.93	0.070	0.076

CASE 45-01

TYPICAL CHARACTERISTICS

(T_A = 25°C unless noted)

FIGURE 1 – REVERSE CURRENT

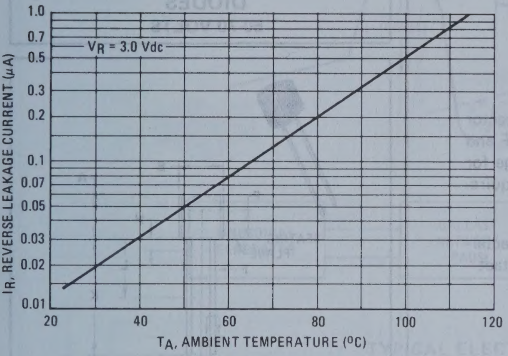


FIGURE 2 – FORWARD VOLTAGE

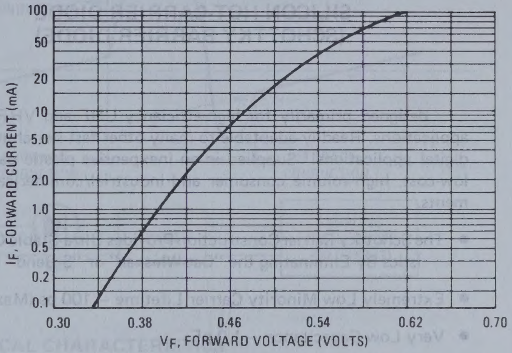


FIGURE 3 – CAPACITANCE

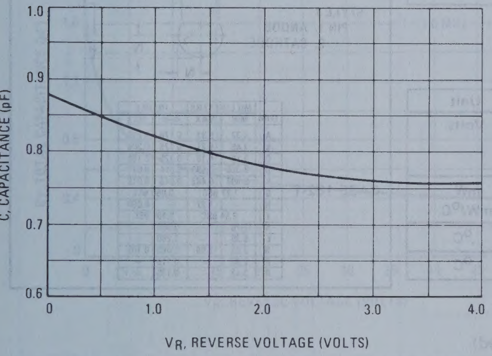


FIGURE 4 – NOISE FIGURE

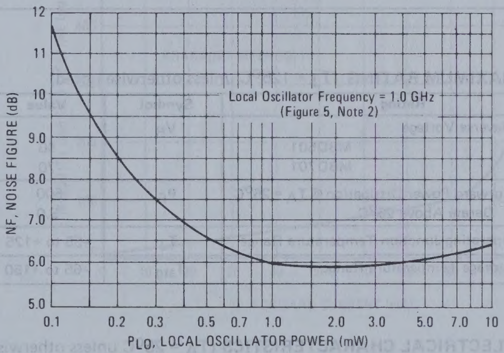
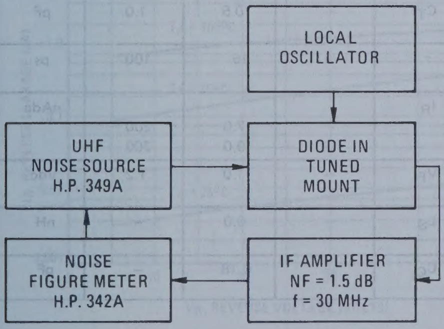


FIGURE 5 – BLOCK DIAGRAM FOR NOISE FIGURE


LOCAL OSCILLATOR
UHF NOISE SOURCE H.P. 349A
DIODE IN TUNED MOUNT
NOISE FIGURE METER H.P. 342A
IF AMPLIFIER NF = 1.5 dB f = 30 MHz

NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBD501 (SILICON)
MBD701

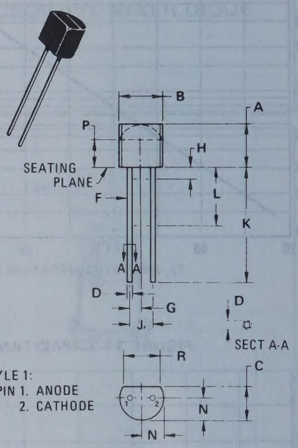
SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in an inexpensive plastic package for low-cost, high-volume consumer and industrial/commerical requirements.

- The Schottky Barrier Construction Provides Ultra-Stable Characteristics By Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime — 100 ps (Max)
- Very Low Capacitance — 1.0 pF
- High Reverse Voltage — to 70 Volts
- Low Reverse Leakage — 200 nA (Max)

HIGH-VOLTAGE SILICON HOT-CARRIER DETECTOR AND SWITCHING DIODES

50-70 VOLTS



STYLE 1:
PIN 1. ANODE
2. CATHODE

CASE 182-1

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

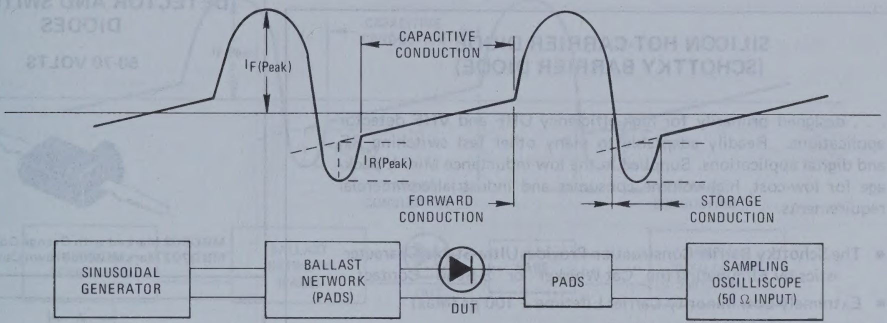
MAXIMUM RATING (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage MBD501 MBD701	V_R	 50 70	Volts
Forward Power Dissipation @ T_A = 25°C Derate Above 25°C	P_F	500 5.0	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	 MBD501 MBD701	$V_{(BR)R}$	 50 70	 — —	 — —	Volts
Total Capacitance, Figure 1 (V_R = 20 Volts, f = 1.0 MHz)		C_T	—	0.5	1.0	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)		τ	—	15	100	ps
Reverse Leakage, Figure 3 (V_R = 25 V) (V_R = 35 V)	 MBD501 MBD701	I_R	 — —	 7.0 9.0	 200 200	nAdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)		V_F	—	1.0	1.2	Vdc
Series Inductance (f = 250 MHz, Lead Lenth ≈ 1/16")		L_S	–	6.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Lenth ≈ 1/16")		C_C	—	0.18	—	pF

KRAKAUER METHOD OF MEASURING LIFE TIME


I_F(Peak)
CAPACITIVE CONDUCTION
I_R(Peak)
FORWARD CONDUCTION
STORAGE CONDUCTION
SINUSOIDAL GENERATOR
BALLAST NETWORK (PADS)
DUT
PADS
SAMPLING OSCILLISCOPE (50 Ω INPUT)

TYPICAL ELECTRICAL CHARACTERISTICS

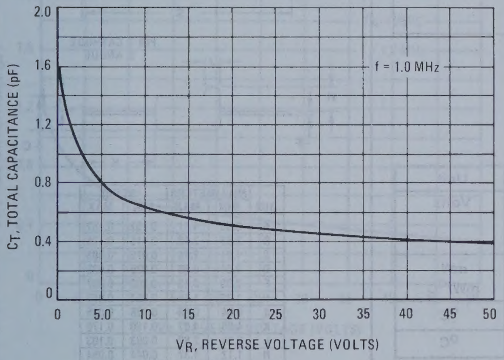


FIGURE 1 – TOTAL CAPACITANCE

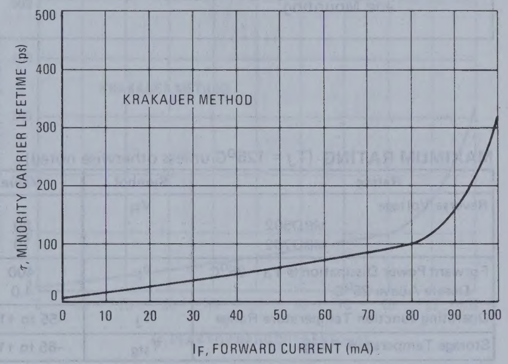


FIGURE 2 – MINORITY CARRIER LIFETIME

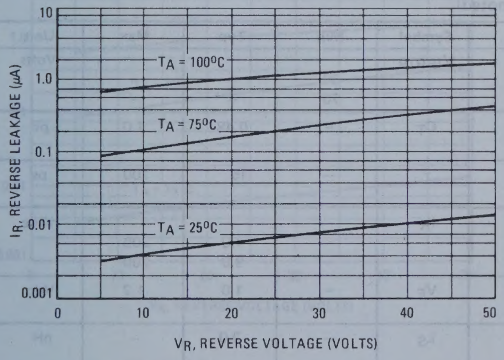


FIGURE 3 – REVERSE LEAKAGE

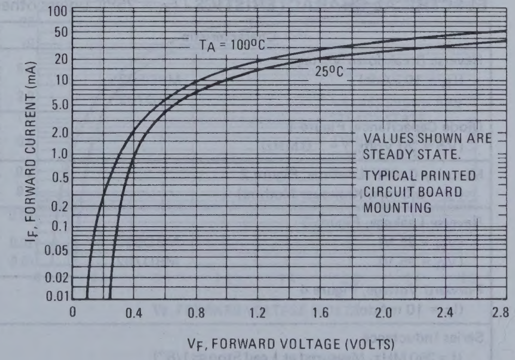


FIGURE 4 – FORWARD VOLTAGE

MBD502 (SILICON)
MBD702

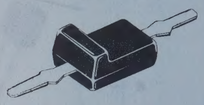
SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in the low-inductance Mini-L package for low-cost, high-volume consumer and industrial/commercial requirements.

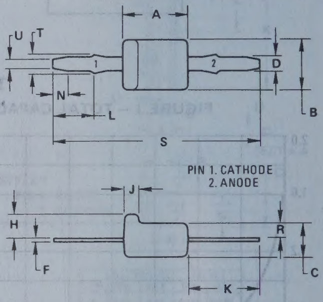
- The Schottky Barrier Construction Provides Ultra-Stable Characteristics by Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime – 100 ps (Max)
- Very Low Capacitance – 1.0 pF
- High Reverse Voltage – to 70 Volts
- Low Reverse Leakage – 200 nA (Max)
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting

HIGH-VOLTAGE SILICON HOT-CARRIER DETECTOR AND SWITCHING DIODES

50-70 VOLTS



MBD502 Marked with Orange Color Stripe
MBD702 Marked with Brown Color Stripe



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

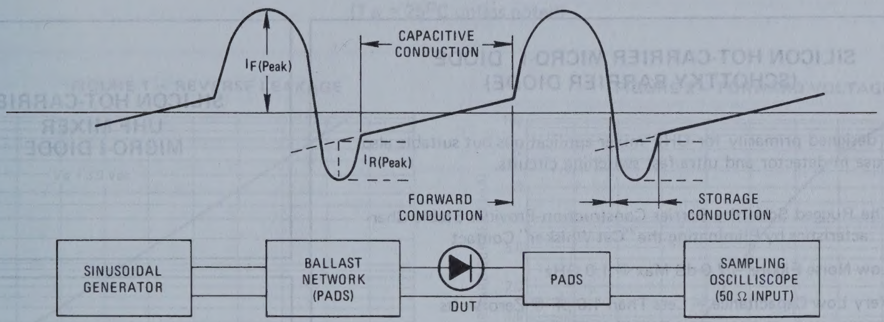
MAXIMUM RATING (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R		Volts
MBD502		50	
MBD702		70	
Forward Power Dissipation @ T_A = 25°C	P_F	400	mW
Derate Above 25°C		4.0	mW/°C
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)		$V_{(BR)R}$				Volts
	MBD502		50	–	–	
	MBD702		70	–	–	
Diode Capacitance, Figure 1 (V_R = 20 Volts, f = 1.0 MHz)		C_T	–	0.48	1.0	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)		τ	–	15	100	ps
Reverse Leakage, Figure 3		I_R				nAdc
(V_R = 25 V)	MBD502		–	7.0	200	
(V_R = 35 V)	MBD702		–	9.0	200	
Forward Voltage, Figure 4 (I_F = 10 mAdc)		V_F	–	1.0	1.2	Vdc
Series Inductance (f = 250 MHz, Measured at Lead Stop ≈ 1/8")		L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)		C_C	–	0.1	–	pF

KRAKAUER METHOD OF MEASURING LIFE TIME


$I_{F(Peak)}$
CAPACITIVE CONDUCTION
$I_{R(Peak)}$
FORWARD CONDUCTION
STORAGE CONDUCTION
SINUSOIDAL GENERATOR
BALLAST NETWORK (PADS)
DUT
PADS
SAMPLING OSCILLISCOPE (50 Ω INPUT)

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – DIODE CAPACITANCE

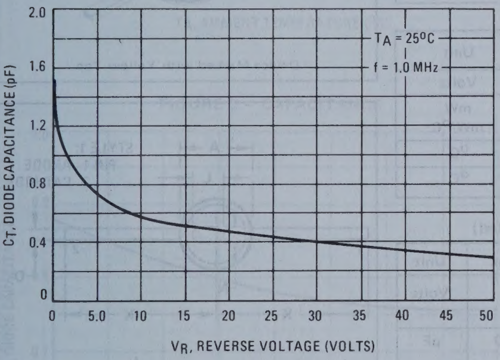


FIGURE 2 – MINORITY CARRIER LIFETIME

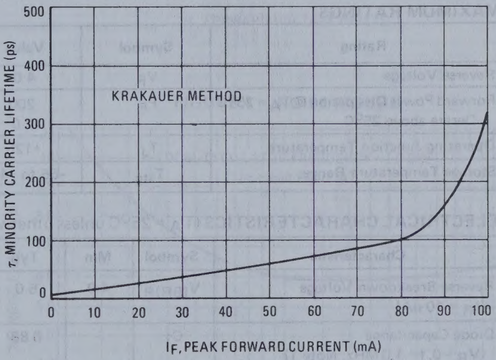


FIGURE 3 – REVERSE LEAKAGE

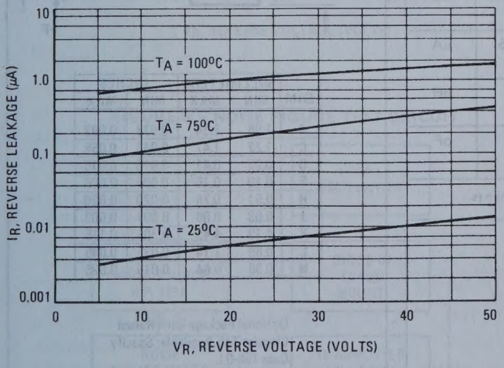
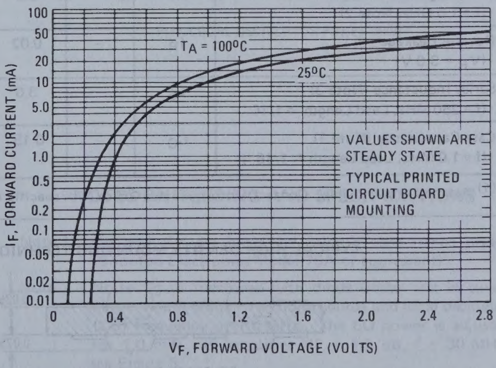


FIGURE 4 – FORWARD VOLTAGE



MBI-101 (SILICON)

SILICON HOT-CARRIER MICRO-I DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure — 7.0 dB Max @ 1.0 GHz
- Very Low Capacitance — Less Than 1.0 pF @ Zero Volts
- High Forward Conductance — 0.48 Volts (Typ) @ I_F = 10 mA
- Supplied in Space Saving Miniature Package

MAXIMUM RATINGS

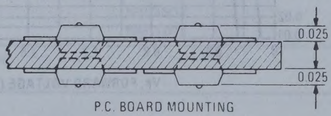
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	200 2.0	mW mW/°C
Operating Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	—	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	—	0.88	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F(1)	—	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	—	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	—	0.02	0.25	μA
Series Inductance (Note 3) (f = 250 MHz, Lead Length ≈ 1/16")	L_S	—	3.0	—	nH
Case Capacitance (Note 1) (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	—	0.15	—	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.

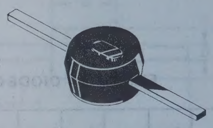
TYPICAL HIGH DENSITY MOUNTING TECHNIQUE



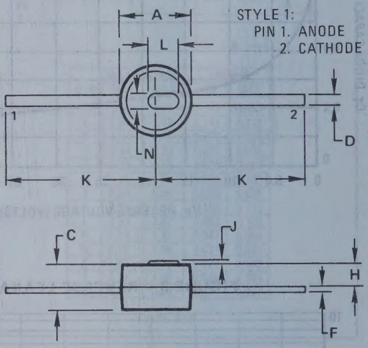
P.C. BOARD MOUNTING

Maximum Solder Temperature:
250°C for 10s

SILICON HOT-CARRIER UHF MIXER MICRO-I DIODE



Device Marked with Yellow Top.



STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
C	1.22	1.47	0.048	0.058
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
L	0.89	1.14	0.035	0.045
N	0.38	0.64	0.015	0.025

Optional Package with Raised Circular Tab Available; Specify Case 166-01.

CASE 166-02

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

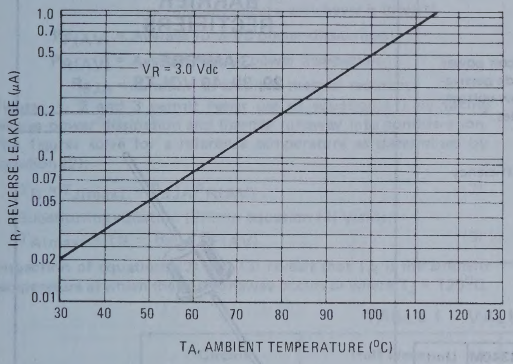


FIGURE 2 – FORWARD VOLTAGE

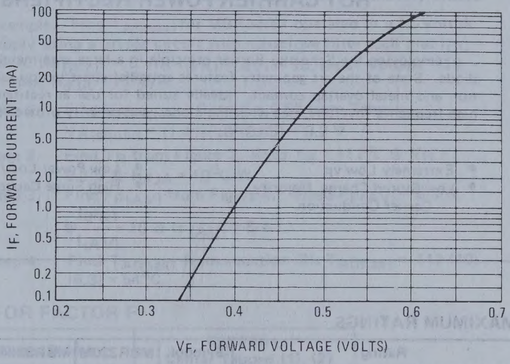


FIGURE 3 – CAPACITANCE

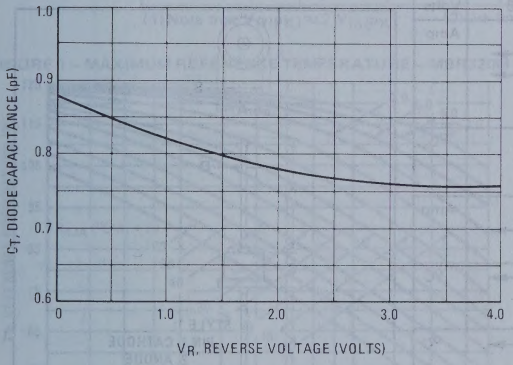


FIGURE 4 – NOISE FIGURE

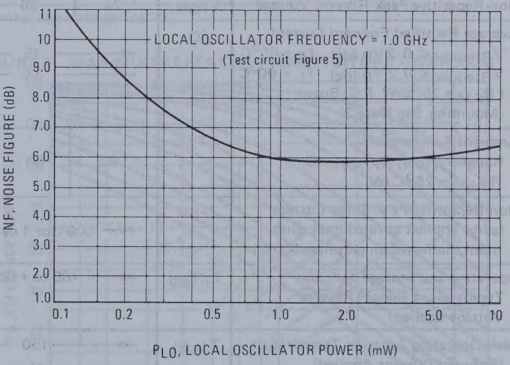
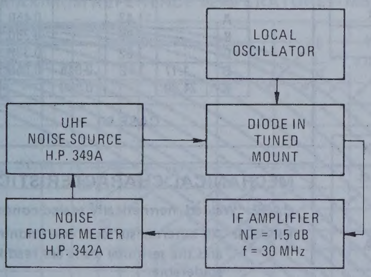


FIGURE 5 – NOISE FIGURE TEST CIRCUIT



LOCAL OSCILLATOR
UHF NOISE SOURCE H.P. 349A
DIODE IN TUNED MOUNT
NOISE FIGURE METER H.P. 342A
IF AMPLIFIER NF = 1.5 dB f = 30 MHz

NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBR320M
MBR330M
MBR340M

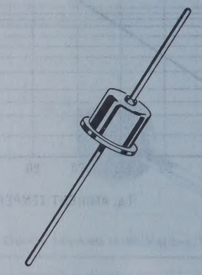
HOT CARRIER POWER RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low V_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

3 AMPERE
20, 30, 40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR320M	MBR330M	MBR340M	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current	I_O				Amp
$V_{R(equiv)} \leqslant 0.2\,V_R$ (dc), $T_C = 65^oC$		← 15 →			
$V_{R(equiv)} \leqslant 0.2\,V_R$ (dc), $T_L = 90^oC$ ($R_{\theta JA} = 25^oC/W$, P.C. Board Mounting, See Note 3)		← 3.0 →			
Ambient Temperature Rated V_R (dc), $P_{F(AV)} = 0$ $R_{\theta JA} = 25^oC/W$	T_A	65	60	55	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}	← −65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

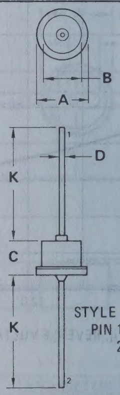
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (I_F = 5.0 Amp)	V_F	–	–	0.450	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1)	I_R				mA
$T_C = 25^oC$		–	–	10	
$T_C = 100^oC$		–	–	75	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal leads are readily solderable.

POLARITY: Cathode to case.

MOUNTING POSITIONS: Any

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\,P_{F(AV)} - R_{\theta JA}\,P_{R(AV)} \qquad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\,P_{R(AV)} \qquad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\,P_{F(AV)} \qquad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{IN(PK)} \times F \qquad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR340M operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 10°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.2 V

Step 2: Find T_R from Figure 3. Read T_R = 117°C @ V_R = 9.2 V & $R_{\theta JA}$ = 10°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 6.3 W
@ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 117-(10)(6.3) = 54°C.

TABLE I — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1), (2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$ (2) Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE — MBR320M

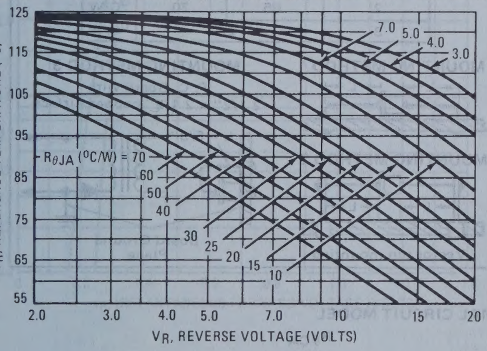


FIGURE 2 — MAXIMUM REFERENCE TEMPERATURE — MBR330M

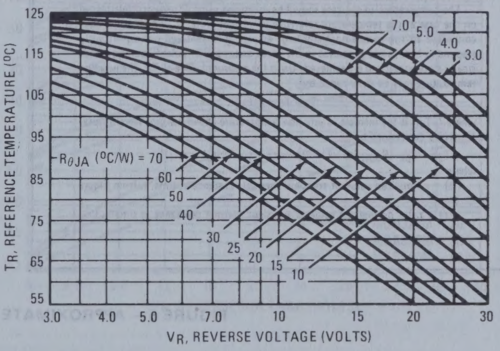


FIGURE 3 — MAXIMUM REFERENCE TEMPERATURE — MBR340M

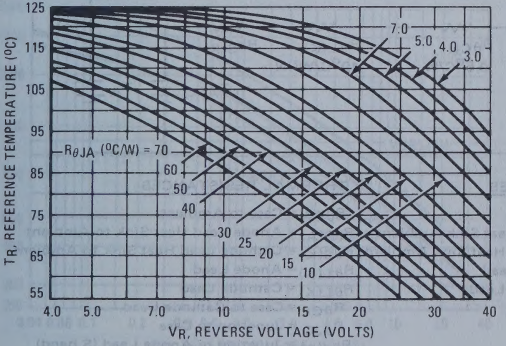
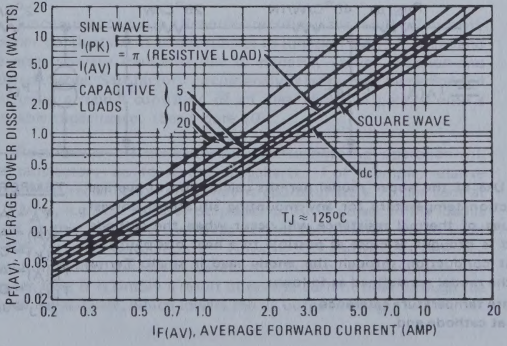
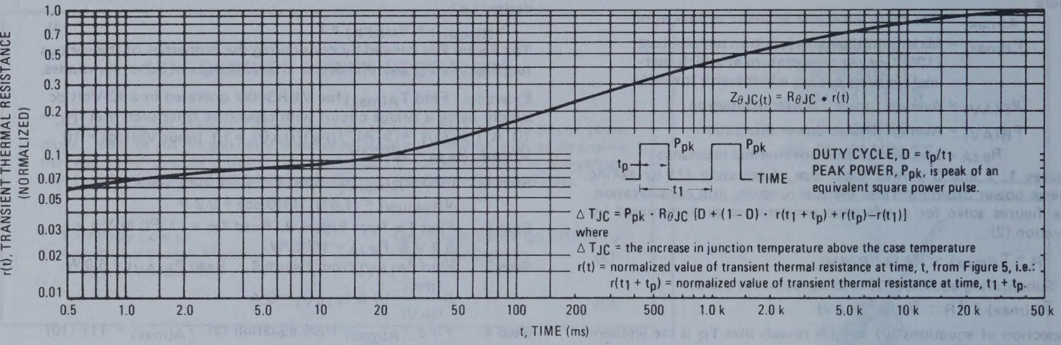


FIGURE 4 — FORWARD POWER DISSIPATION

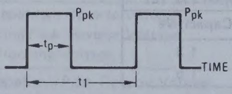


THERMAL CHARACTERISTICS

FIGURE 5 — THERMAL RESPONSE



NOTE 2 — FINDING JUNCTION TEMPERATURE



DUTY CYCLE, D = t_p/t_1
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 5 i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

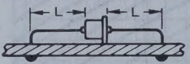
NOTE 3 — MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering.

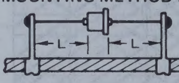
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN) 1/4	1	$R_{\theta JA}$
1	55	60	°C/W
2	65	70	°C/W
3	25		°C/W

MOUNTING METHOD 1



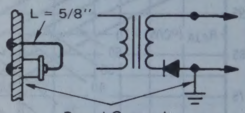
MOUNTING METHOD 2



Vector pin mounting

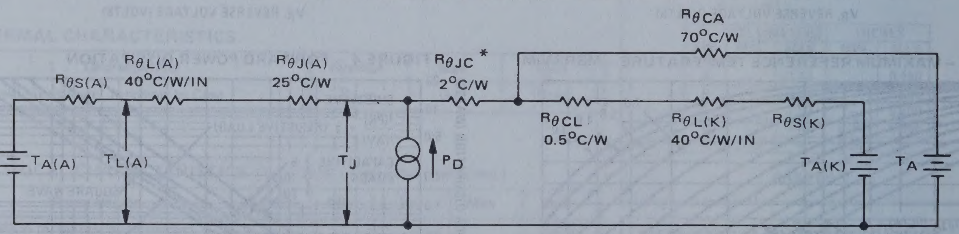
MOUNTING METHOD 3

P. C. Board with
2 1/2'' x 2 1/2'' copper surface



Board Ground Plane

FIGURE 6 — APPROXIMATE THERMAL CIRCUIT MODEL



Use of the above model permits calculation of average junction temperature for any mounting situation. Lowest values of thermal resistance will occur when the cathode lead is brought as close as possible to a heat dissipator; as heat conduction through the anode lead is small. Terms in the model are defined as follows:

*Case temperature reference is at cathode end.

TEMPERATURES

T_A = Ambient
$T_{A(A)}$ = Anode Heat Sink Ambient
$T_{A(K)}$ = Cathode Heat Sink Ambient
$T_{L(A)}$ = Anode Lead
$T_{L(K)}$ = Cathode Lead
T_J = Junction

THERMAL RESISTANCES

$R_{\theta CA}$ = Case to Ambient
$R_{\theta S(A)}$ = Anode Lead Heat Sink to Ambient
$R_{\theta S(K)}$ = Cathode Lead Heat Sink to Ambient
$R_{\theta L(A)}$ = Anode Lead
$R_{\theta L(K)}$ = Cathode Lead
$R_{\theta CL}$ = Case to Cathode Lead
$R_{\theta JC}$ = Junction to Case
$R_{\theta J(A)}$ = Junction to Anode Lead (S bend)

FIGURE 7 – TYPICAL FORWARD VOLTAGE

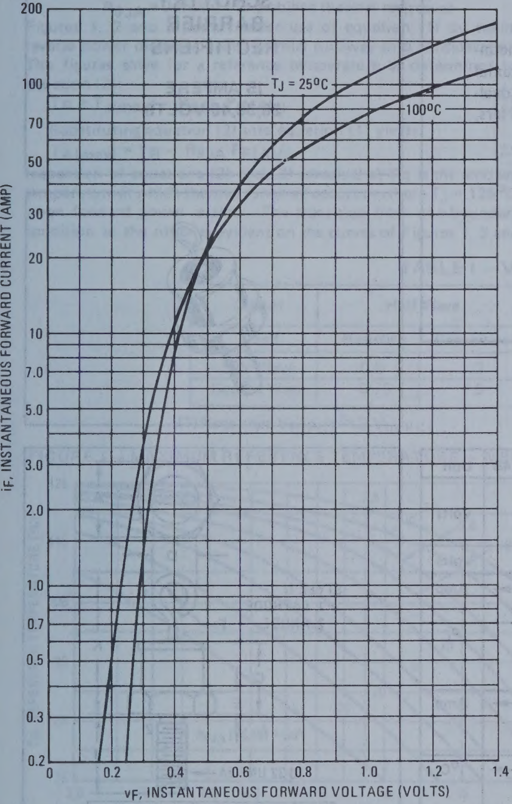


FIGURE 8 – MAXIMUM SURGE CAPABILITY

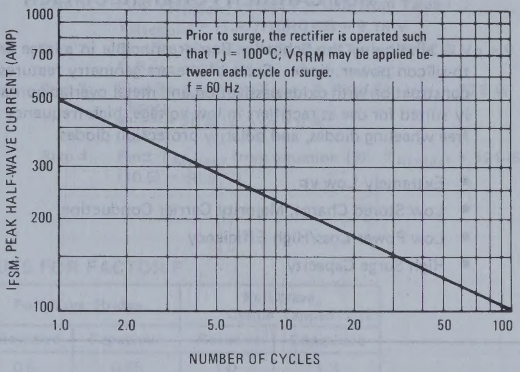


FIGURE 9 – TYPICAL REVERSE CURRENT

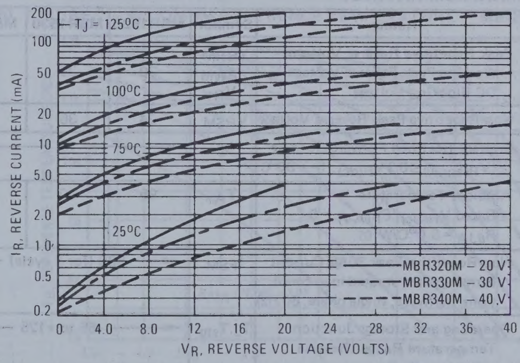
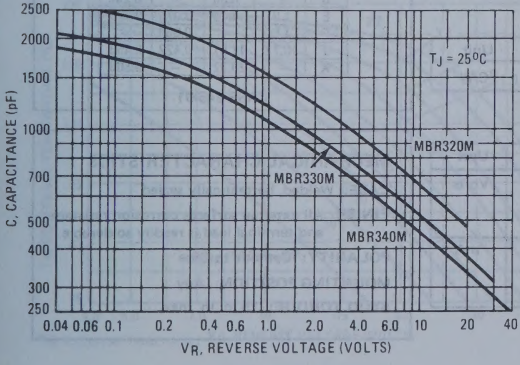


FIGURE 10 – CAPACITANCE



NOTE 4 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 10).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR1520
MBR1530
MBR1540

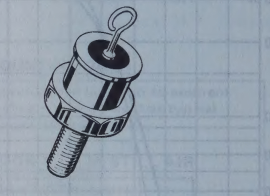
HOT CARRIER POWER RECTIFIER

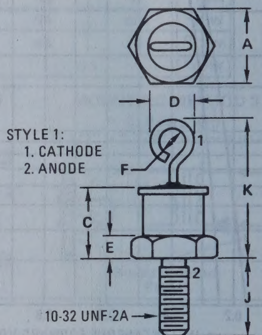
. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

15 AMPERE
20,30,40 VOLTS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245-01

MAXIMUM RATINGS

Rating	Symbol	MBR1520	MBR1530	MBR1540	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current ($V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 80^{\circ}C$)	I_O	15			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 5.0^{\circ}C/W$	T_A	95	90	85	$^{\circ}C$
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	500 (for 1 cycle)			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	-65 to +125			$^{\circ}C$
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	150			$^{\circ}C$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	$^{\circ}C/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 15 Amp)	v_F	–	–	0.550	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^{\circ}C$	I_R	– –	– –	10 75	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 15 in. lb. max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\,P_{F(AV)} - R_{\theta JA}\,P_{R(AV)} \qquad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\,P_{R(AV)} \qquad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\,P_{F(AV)} \qquad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \qquad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR1540 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 121°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 10.5 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 20 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 121-(5)(10.5) = 68.5°C).

TABLE I — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1)(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE — MBR1520

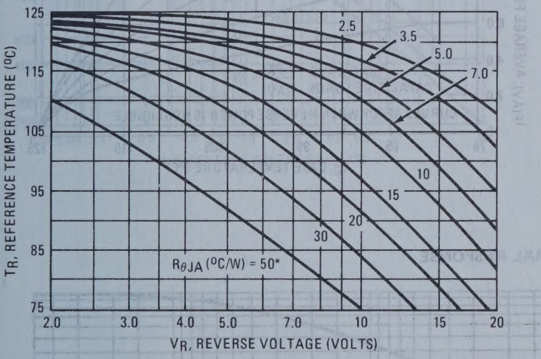


FIGURE 2 — MAXIMUM REFERENCE TEMPERATURE — MBR1530

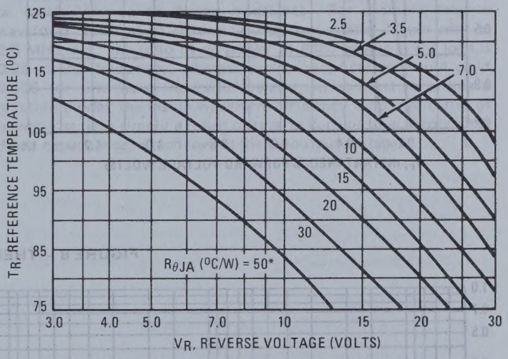
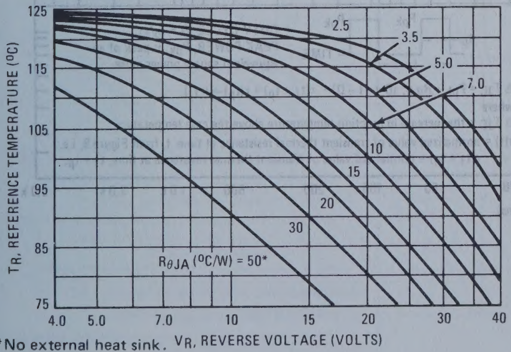


FIGURE 3 — MAXIMUM REFERENCE TEMPERATURE — MBR1540



*No external heat sink.

FIGURE 4 — FORWARD POWER DISSIPATION

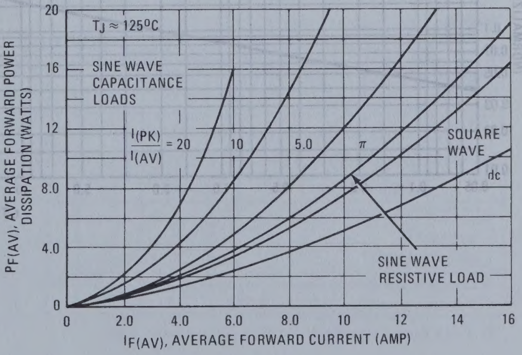


FIGURE 5 — TYPICAL FORWARD VOLTAGE

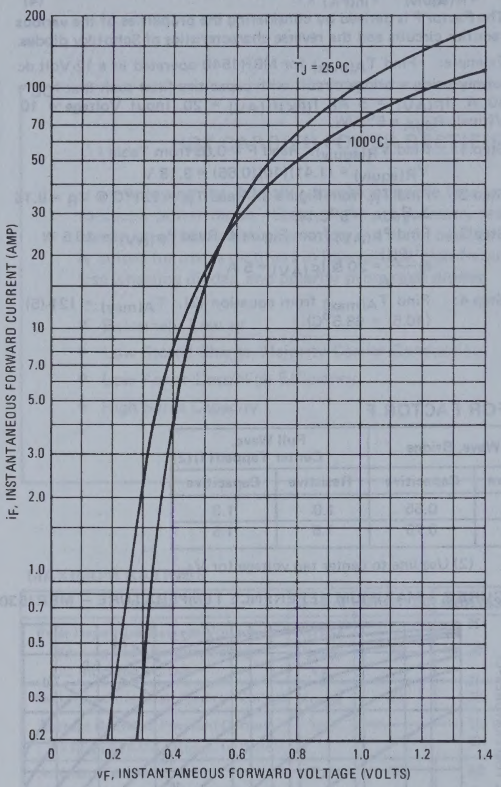


FIGURE 6 — MAXIMUM SURGE CAPABILITY

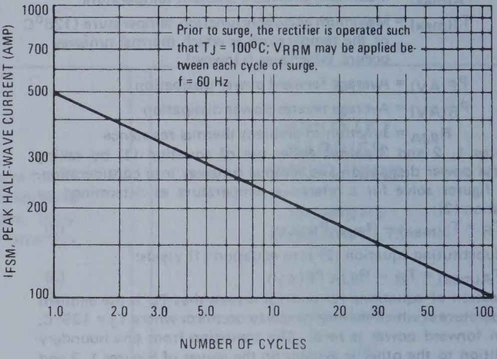
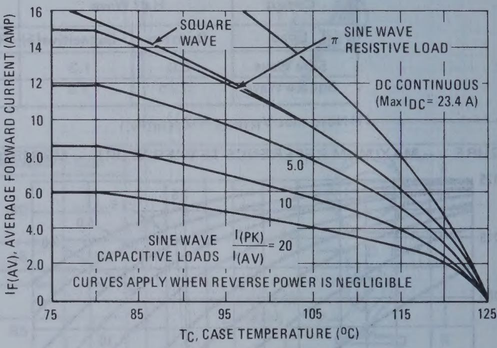
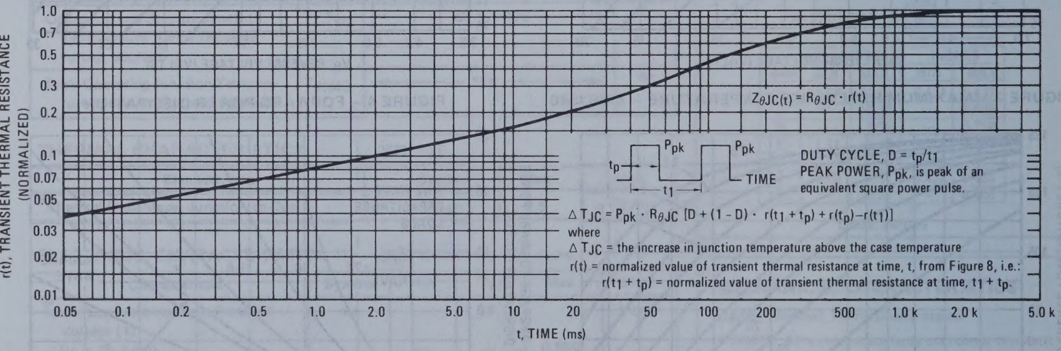

Prior to surge, the rectifier is operated such that $T_J = 100^oC$; V_{RRM} may be applied between each cycle of surge.
f = 60 Hz

FIGURE 7 — CURRENT DERATING



CURVES APPLY WHEN REVERSE POWER IS NEGLIGIBLE

FIGURE 8 — THERMAL RESPONSE


$Z_{\theta JC}(t) = R_{\theta JC} \cdot r(t)$

DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC}\ [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$

where

ΔT_{JC} = the increase in junction temperature above the case temperature

r(t) = normalized value of transient thermal resistance at time, t, from Figure 8, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time, $t_1 + t_p$.

P_{pk}
P_{pk}
t_p
t_1
TIME
r(t), TRANSIENT THERMAL RESISTANCE (NORMALIZED)
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
0.05
0.1
0.2
0.5
1.0
2.0
5.0
10
20
50
100
200
500
1.0 k
2.0 k
5.0 k
t, TIME (ms)

FIGURE 9 – NORMALIZED REVERSE CURRENT

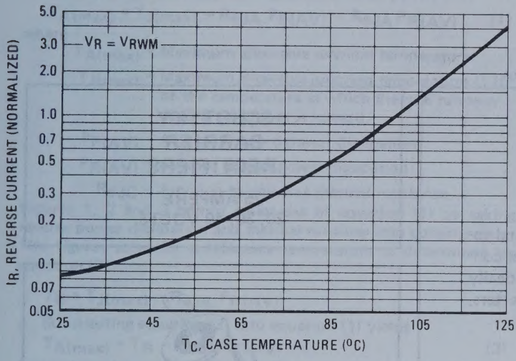


FIGURE 10 – TYPICAL REVERSE CURRENT

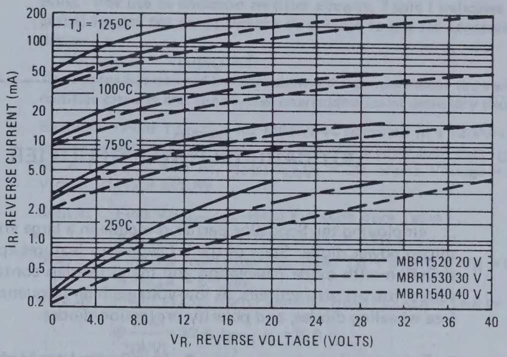
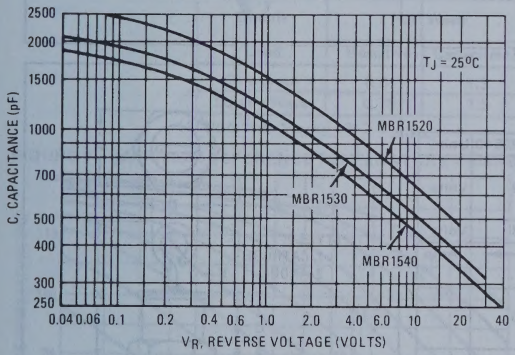


FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR2520
MBR2530
MBR2540

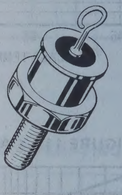
HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

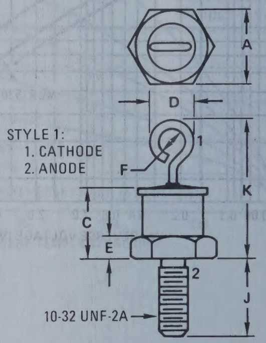
SCHOTTKY BARRIER RECTIFIERS

25 AMPERE
20, 30, 40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR2520	MBR2530	MBR2540	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv.)} \leqslant 0.2\ V_{R(dc)}$, $T_C = 80^oC$	I_O	← 25 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$ $R_{\theta JA} = 3.5^oC/W$	T_A	90	85	80	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	800 (for 1 cycle)			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J\ (pk)}$	← 150 →			^oC



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245-01

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 25 Amp)	v_F	–	–	0.550	Volts
Maximum Instantaneous Reverse Current @ Rated dc Voltage (1) ($T_C = 100^oC$)	i_R	– –	– –	20 150	mA

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistance and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITIONS: Any

STUD TORQUE: 15 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\,P_{F(AV)} - R_{\theta JA}\,P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\,P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\,P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR2540 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 16 A ($I_{F(AV)}$ = 8 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)} = (1.41)(10)(0.65) = 9.18$ V

Step 2: Find T_R from Figure 3. Read T_R = 113°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 14.8 W
@ $\dfrac{I_{(PK)}}{I_{(AV)}} = 20$ & $I_{F(AV)}$ = 8 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 113-(5) (14.8) = 39°C

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1), (2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – MBR2520

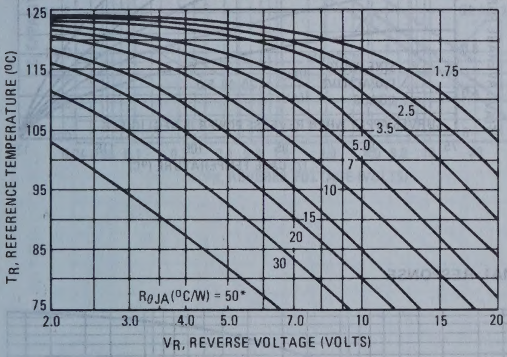


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR2530

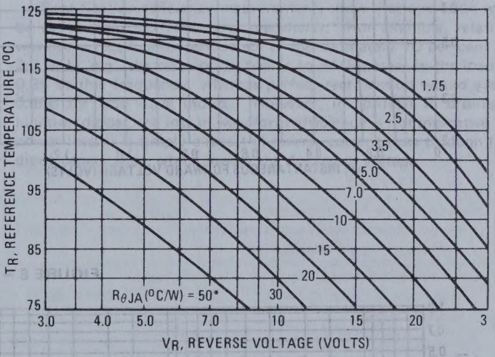


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR2540

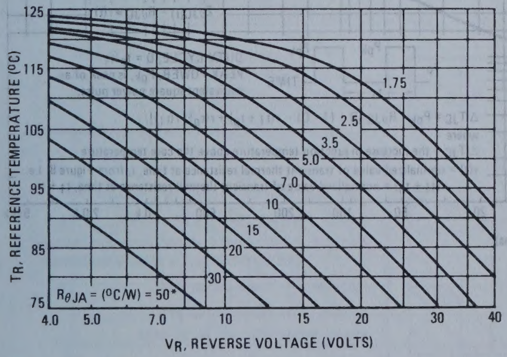
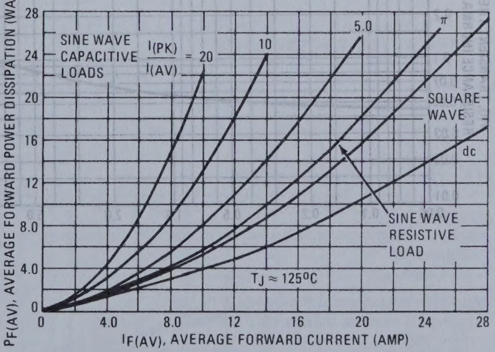


FIGURE 4 – FORWARD POWER DISSIPATION



*No external heat sink

FIGURE 5 – TYPICAL FORWARD VOLTAGE

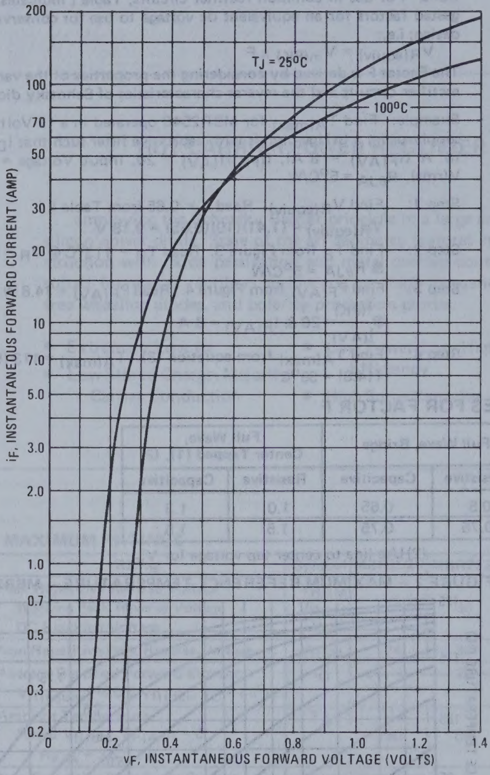


FIGURE 6 – MAXIMUM SURGE CAPABILITY

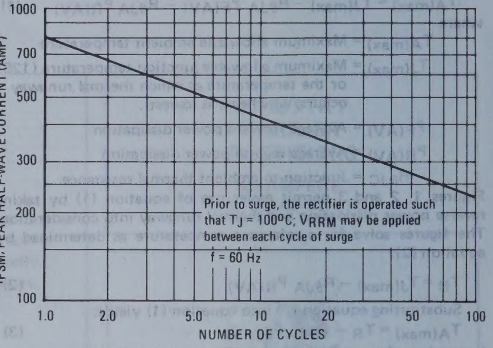


FIGURE 7 – CURRENT DERATING

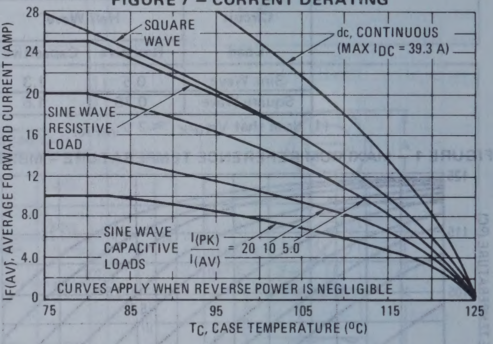


FIGURE 8 – THERMAL RESPONSE

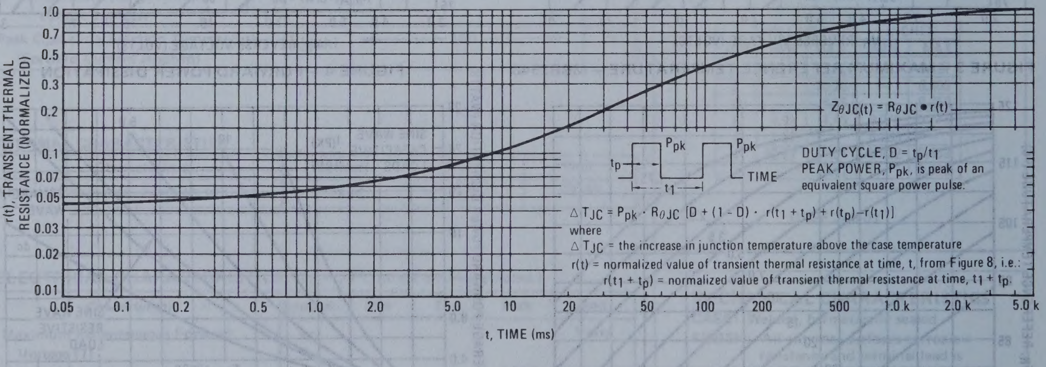


FIGURE 9 – NORMALIZED REVERSE CURRENT

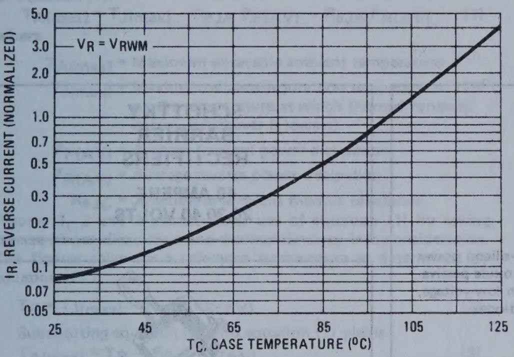


FIGURE 10 – TYPICAL REVERSE CURRENT

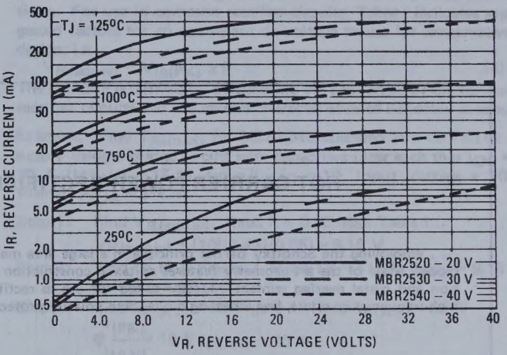
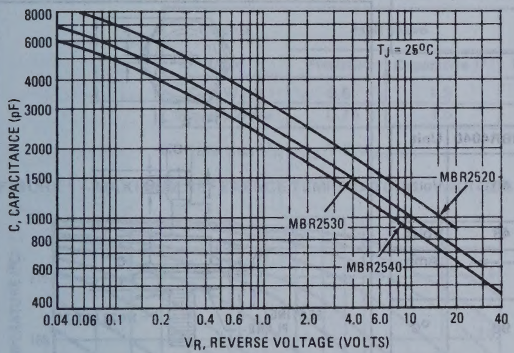


FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR4020
MBR4030
MBR4040

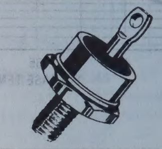
HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

40 AMPERE
20,30,40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR4020	MBR4030	MBR4040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 70^oC$	I_O	◄— 40 —►			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 2.0^oC/W$	T_A	100	95	90	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	◄— 800 (for 1 cycle) —►			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	◄— -65 to +125 —►			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	◄— 150 —►			^oC

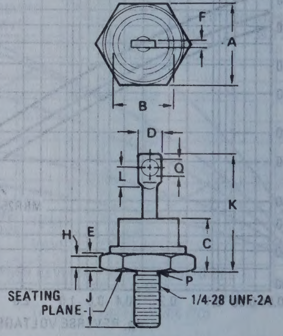
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 40 Amp)	v_F	–	–	0.630	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^oC$	I_R	– –	– –	20 150	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.94	17.45	0.667	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
H	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.96	–	0.152	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175

NOTES:
1. Dimension "P" is diameter.
2. All JEDEC dimensions and notes apply.

CASE 257-01
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\, P_{F(AV)} - R_{\theta JA}\, P_{R(AV)} \qquad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\, P_{R(AV)} \qquad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\, P_{F(AV)} \qquad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \qquad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR4040 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 30 A ($I_{F(AV)}$ = 15 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 3°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)}$ = (10)(1.41)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 118°C @ V_R = 9.18 V & $R_{\theta JA}$ = 3°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 25 W
@ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 15 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 118-(3)(25) = 43°C.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\, V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – MBR4020

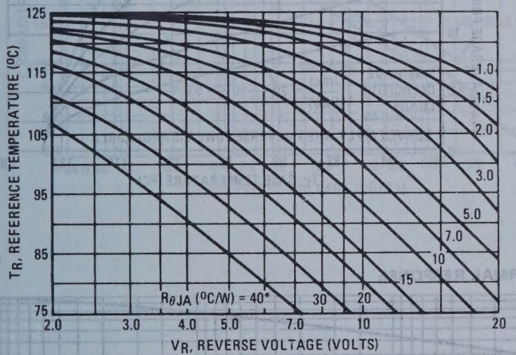


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR4030

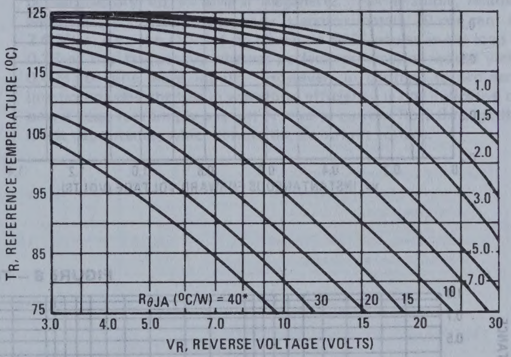
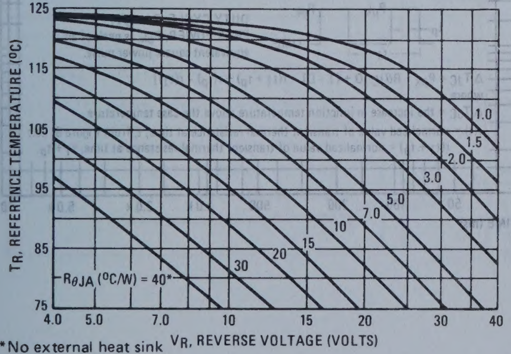


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR4040



*No external heat sink

FIGURE 4 – FORWARD POWER DISSIPATION

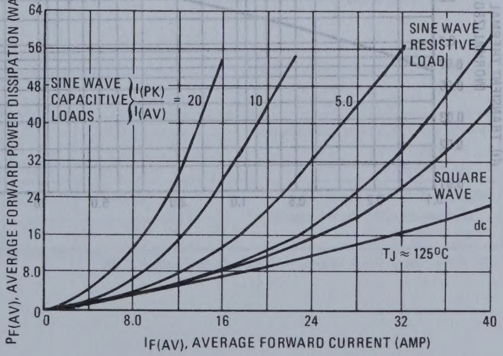


FIGURE 5 – TYPICAL FORWARD VOLTAGE

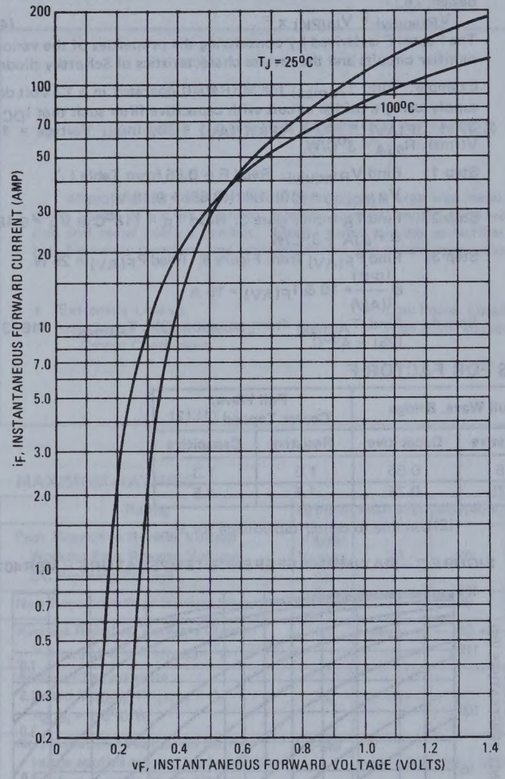
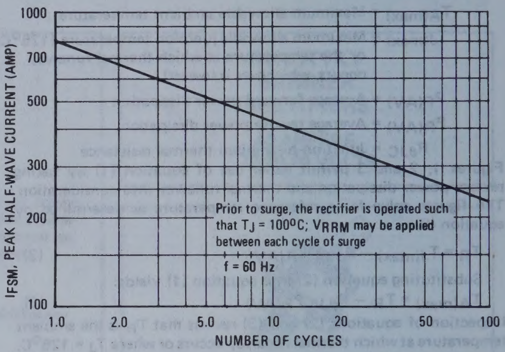


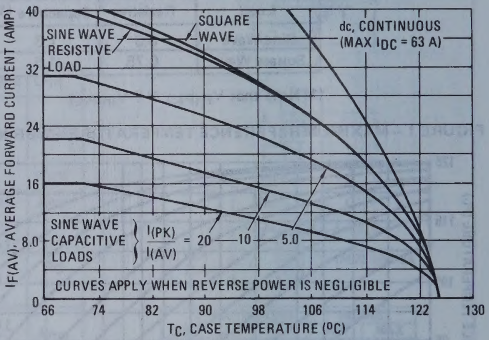
FIGURE 6 – MAXIMUM SURGE CAPABILITY



Prior to surge, the rectifier is operated such that $T_J = 100^\circ C$; V_{RRM} may be applied between each cycle of surge

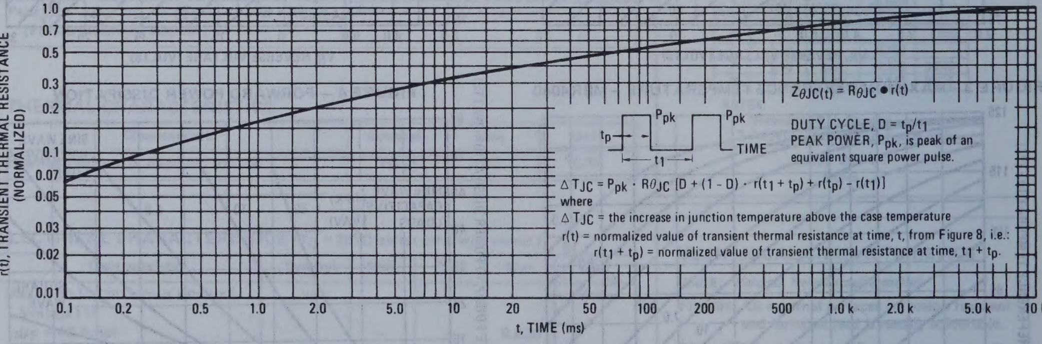
f = 60 Hz

FIGURE 7 – CURRENT DERATING



CURVES APPLY WHEN REVERSE POWER IS NEGLIGIBLE

FIGURE 8 – THERMAL RESPONSE



$Z_{\theta JC}(t) = R_{\theta JC} \bullet r(t)$

DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$

where

ΔT_{JC} = the increase in junction temperature above the case temperature

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 8, i.e.:
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time, $t_1 + t_p$.

FIGURE 9 – NORMALIZED REVERSE CURRENT

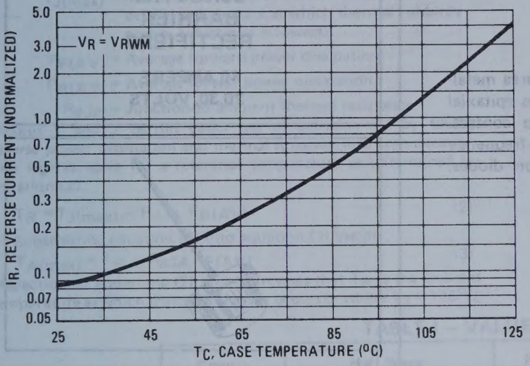


FIGURE 10 – TYPICAL REVERSE CURRENT

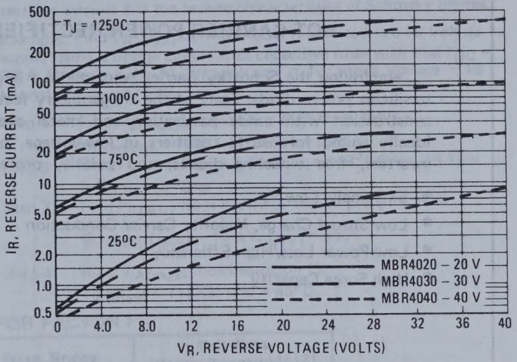
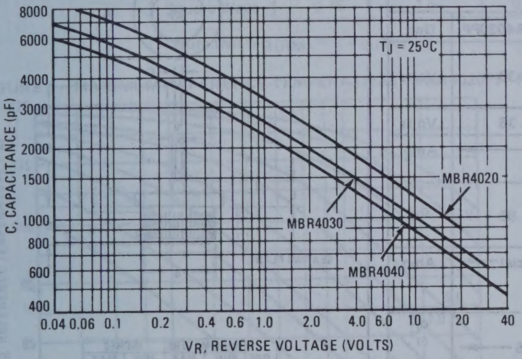


FIGURE 11 – CAPACITANCE



NOTE 2 HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR4020PF
MBR4030PF

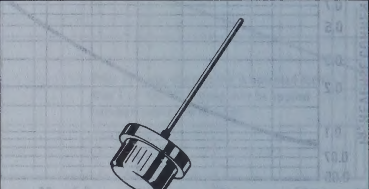
HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

40 AMPERE
20,30, VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR4020PF	MBR4030PF	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	Volts
Average Rectified Forward Current $V_{R(equiv)} \leqslant 0.2\ V_{R(dc)}, T_C = 50^\circ C$	I_O	← 40 →		Amp
Ambient Temperature Rated $V_{R(dc)}, P_{F(AV)} = 0$, $R_{\theta JA} = 2.0^\circ C/W$	T_A	100	95	°C
Non-Repetitive Peak Surge Current (surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 800 (for 1 cycle) →		Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →		°C
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →		°C

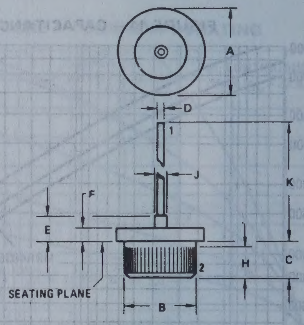
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) ($i_F = 40$ Amp)	v_F	–	0.57	0.630	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^\circ C$	i_R	– –	– –	20 150	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.494	16.256	0.610	0.640
B	12.725	12.827	0.501	0.505
C	5.08	6.35	0.200	0.250
D	1.193	1.346	0.047	0.053
E	–	10.77	–	0.424
F	2.032	4.826	0.080	0.190
H	4.572	6.350	0.180	0.250
J	–	3.556	–	0.140
K	12.70	–	0.500	–

CASE 43-02
DO-21

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and terminal lead is readily solderable.

POLARITY: Cathode to Case

MOUNTING POSITION: Any

WEIGHT: 9 grams (Approximately)

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\, P_{F(AV)} - R_{\theta JA}\, P_{R(AV)} \qquad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature
$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).
$P_{F(AV)}$ = Average forward power dissipation
$P_{R(AV)}$ = Average reverse power dissipation
$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1 and 2 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\, P_{R(AV)} \qquad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\, P_{F(AV)} \qquad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1 and 2 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1 and 2 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \qquad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR4030PF operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 30 A ($I_{F(AV)}$ = 15 A), $I_{(FM)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 3°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)}$ = (10)(1.41)(0.65) = 9.18 V

Step 2: Find T_R from Figure 2. Read T_R = 118°C @ V_R = 9.18 V & $R_{\theta JA}$ = 3°C/W

Step 3: Find $P_{F(AV)}$ from Figure 3. Read $P_{F(AV)}$ = 25 W
@ $I_{(FM)}/I_{(AV)}$ = 10 & $I_{F(AV)}$ = 15 A

Step 4: Find $T_{A(max)}$ from equation (3).
$T_{A(max)}$ = 118-(3) (25) = 43°C.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(RM)} \approx 2\, V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE–MBR4020PF

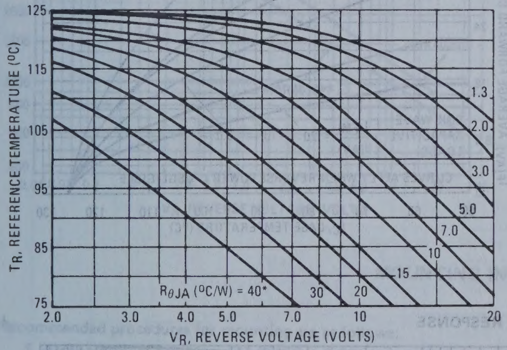
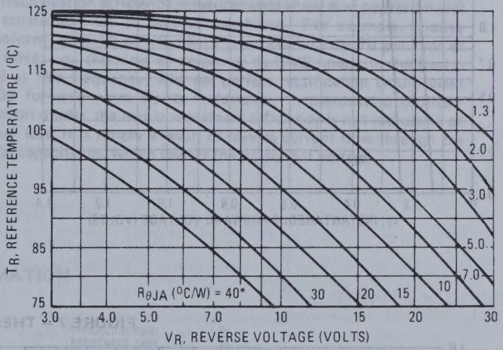


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE–MBR4030PF



*No external heat sink.

FIGURE 3 – FORWARD POWER DISSIPATION

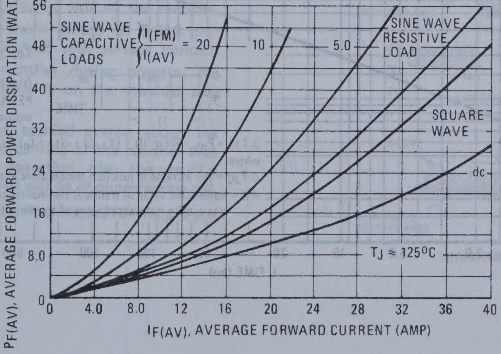


FIGURE 4 – TYPICAL FORWARD VOLTAGE

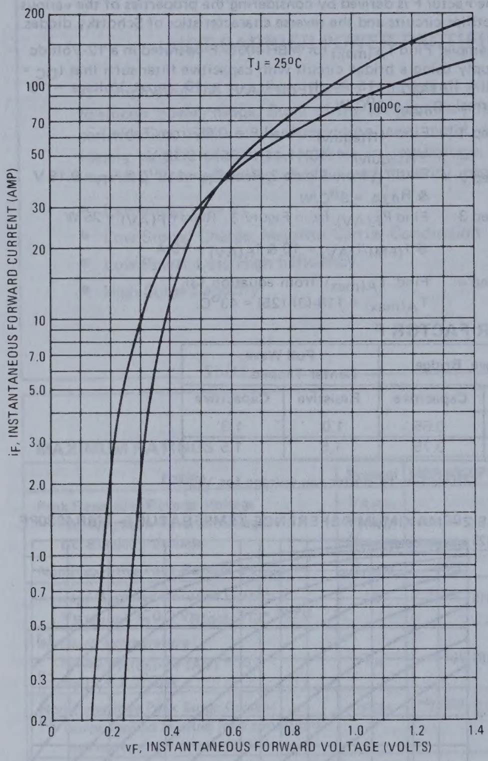
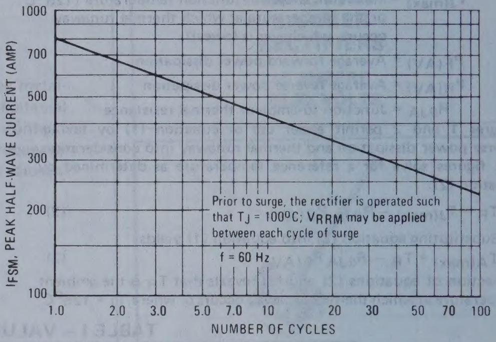


FIGURE 5 – MAXIMUM NON-REPETITIVE SURGE CAPABILITY



Prior to surge, the rectifier is operated such that $T_J = 100^{\circ}C$; V_{RRM} may be applied between each cycle of surge

f = 60 Hz

FIGURE 6 – CURRENT DERATING

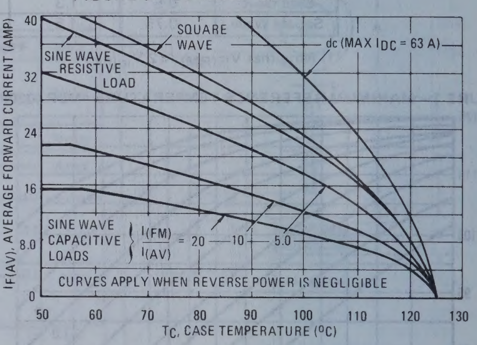
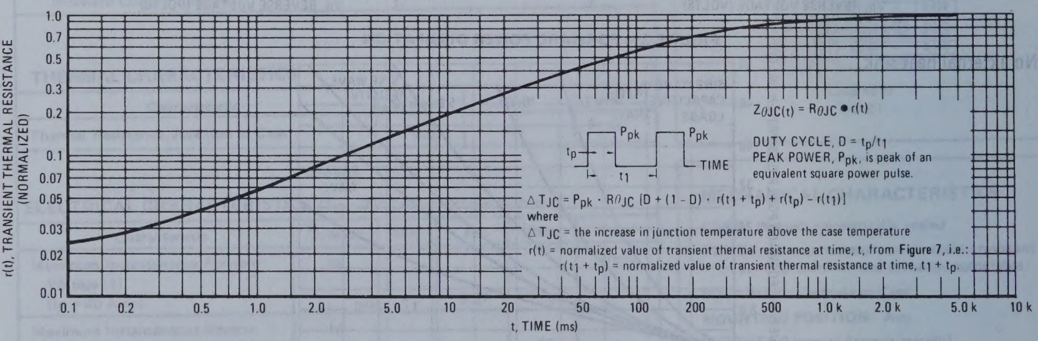


FIGURE 7 – THERMAL RESPONSE



$Z_{\theta JC}(t) = R_{\theta JC} \bullet r(t)$

DUTY CYCLE, $D = t_p/t_1$

PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$

where

ΔT_{JC} = the increase in junction temperature above the case temperature

r(t) = normalized value of transient thermal resistance at time, t, from Figure 7, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time, $t_1 + t_p$.

FIGURE 8 – NORMALIZED REVERSE CURRENT

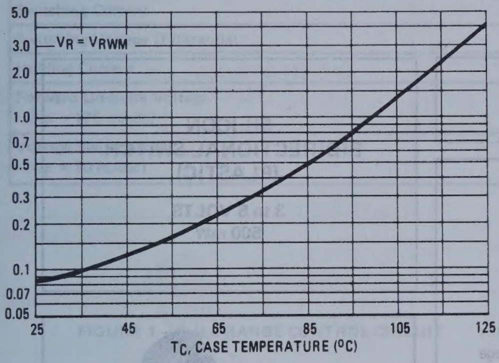


FIGURE 9 – TYPICAL REVERSE CURRENT

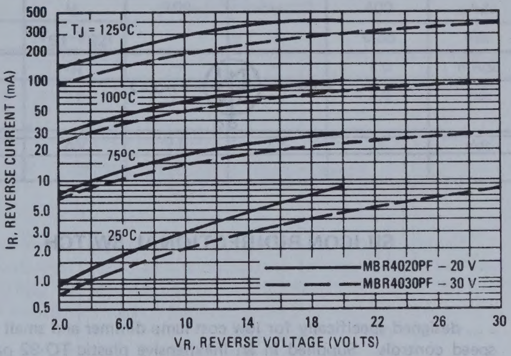
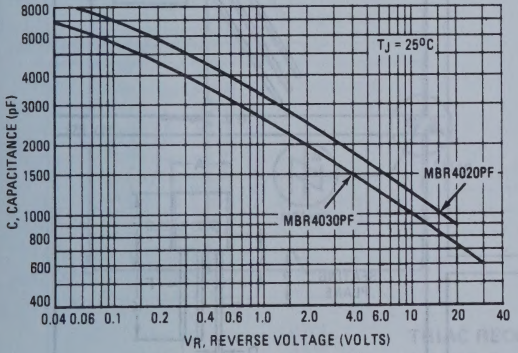


FIGURE 10 – CAPACITANCE



NOTE 2 HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 10).

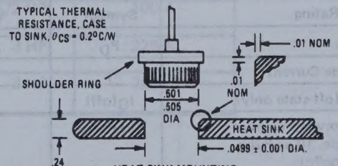
Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MOUNTING INFORMATION

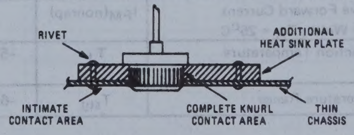
Recommended procedures for mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± 0.001 inch in diameter.
2. Break the hole edge as shown to provide a guide into the hole and prevent shearing off the knurled side of the rectifier.
3. The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.
4. To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case.
5. The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a thermal lubricant such as D.C. 340 will be of considerable aid.

For more information see: Mounting Techniques for Metal Packaged Power Semiconductors, AN-599.

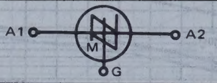


HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

MBS100 (SILICON)



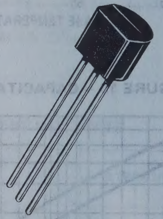
SILICON BIDIRECTIONAL SWITCH (PLASTIC)

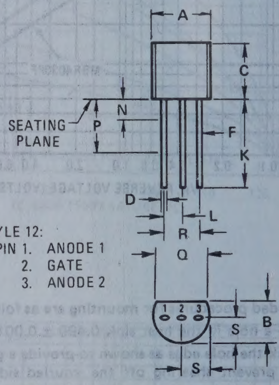
3 to 5 VOLTS
500 mW

SILICON BIDIRECTIONAL SWITCH

. . . designed specifically for low cost lamp dimmer and small motor speed controls. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

- Low Switching Voltage — 4.0 Volts Typical
- Uniform Characteristics in Each Direction
- Minimizes "Flash-On" in a Lamp Dimmer
- Minimizes "Cogging" in a Motor Speed Control





STYLE 12:
PIN 1. ANODE 1
2. GATE
3. ANODE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

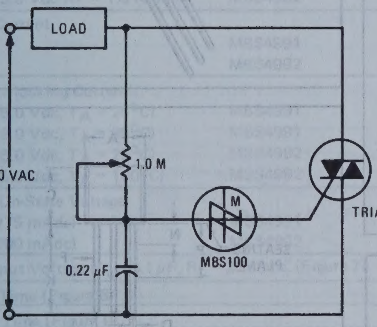
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation	P_D	500	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	$I_{G(off)}$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, T_A = 100°C)	$I_{FM(rep)}$	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, T_A = 25°C	$I_{FM(nonrep)}$	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Switching Voltage	V_S	3.0	4.0	5.0	Vdc
Switching Current	I_S	100	–	400	µAdc
Switching Voltage Differential	$\|V_{S1}-V_{S2}\|$	–	–	0.35	Vdc
Holding Current	I_H	–	–	1.0	mAdc
Forward On-State Voltage (I_F = 175 mAdc)	V_F	–	–	2.0	Vdc
Voltage Switchback (I_F = 10 mAdc)	ΔV	2.0	2.8	–	Vdc

FIGURE 1 – FULL RANGE CONTROL CIRCUIT



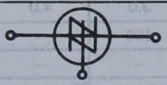
APPLICATION NOTE

The circuit shown in Figure 1 is for full range control and may be used as a lamp dimmer or small motor speed control. Lamp "flash-on" and motor "cogging" is minimized. Suggested triacs listed below give power capacity available for each device. The in-rush current and/or motor locked rotor current must be within the maximum multicycle surge rating for the triacs suggested.

TRIAC RECOMMENDATIONS

Triac	Package Type	Maximum Lamp Load	Maximum Motor Load	Maximum Single Cycle Surge
MAC77-4/2N6071	Case 77 (Plastic)	500 Watts	1/2 HP	30 A
MAC11-4	Case 90 (Plastic)	1500 Watts	1-1/2 HP	100 A
MAC37-4	Case 174 (Pressfit)	3000 Watts	3 HP	225 A
MAC38-4	Case 175 (Stud)	3000 Watts	3 HP	225 A

MBS4991 (SILICON)
MBS4992



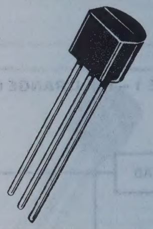
SILICON BIDIRECTIONAL SWITCH (PLASTIC)

6.0–10 VOLTS
500 mW

SILICON BIDIRECTIONAL SWITCH

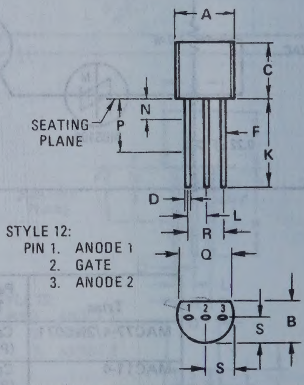
. . . designed for full-wave triggering in Triac phase control circuits, half-wave SCR triggering application and as voltage level detectors. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

- Low Switching Voltage – 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage – 1.7 Volts Maximum
- Low Off-State Current – 0.1 μA Maximum
- Low Temperature Coefficient – 0.02 %/°C Typical



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation	P_D	500	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	$I_{G(off)}$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, T_A = 100°C)	$I_{FM(rep)}$	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, T_A = 25°C	$I_{FM(nonrep)}$	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



STYLE 12:
PIN 1. ANODE 1
2. GATE
3. ANODE 2

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Switching Voltage	MBS4991 MBS4992	V_S	6.0 7.5	8.0 8.0	10 9.0	Vdc
Switching Current	MBS4991 MBS4992	I_S	– –	175 90	500 120	μAdc
Switching Voltage Differential	MBS4991 MBS4992	$\lvert V_{S1}-V_{S2}\rvert$	– –	0.3 0.1	0.5 0.2	Vdc
Gate Trigger Current (V_F = 5.0 Vdc R_L = 1.0 K ohm)	MBS4992	I_{GF}	–	–	100	μAdc
Holding Current	MBS4991 MBS4992	I_H	– –	0.7 0.2	1.5 0.5	mAdc
Off-State Blocking Current (V_F = 5.0 Vdc, $T_A = 25^{\circ}C$) (V_F = 5.0 Vdc, $T_A = 85^{\circ}C$) (V_F = 5.0 Vdc, $T_A = 25^{\circ}C$) (V_F = 5.0 Vdc, $T_A = 100^{\circ}C$)	MBS4991 MBS4991 MBS4992 MBS4992	I_B	– – – –	0.08 2.0 0.08 6.0	1.0 10 0.1 10	μAdc
Forward On-State Voltage (I_F = 175 mAdc) (I_F = 200 mAdc)	MBS4991 MBS4992	V_F	– –	1.4 1.5	1.7 1.7	Vdc
Peak Output Voltage (C_c = 0.1 μF, R_L = 20 ohms, (Figure 7)		V_o	3.5	4.8	–	Vdc
Turn-On Time (Figure 8)		t_{on}	–	1.0	–	μs
Turn-Off Time (Figure 9)		t_{off}	–	30	–	μs
Temperature Coefficient of Switching Voltage (-50 to +125°C)		T_C	–	+0.02	–	%/°C

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE versus TEMPERATURE

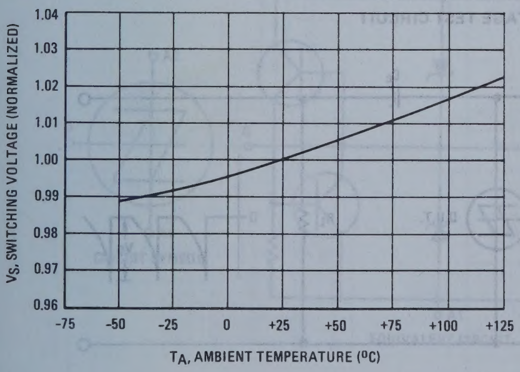


FIGURE 2 – SWITCHING CURRENT versus TEMPERATURE

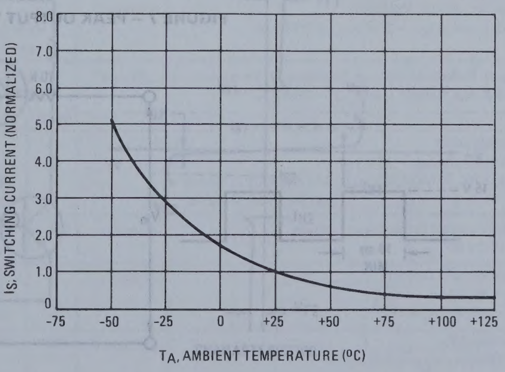


FIGURE 3 – HOLDING CURRENT versus TEMPERATURE

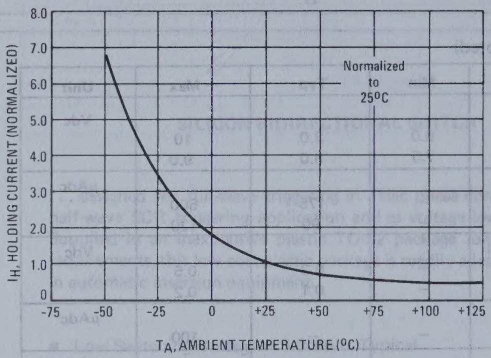


FIGURE 4 – OFF-STATE BLOCKING CURRENT versus TEMPERATURE

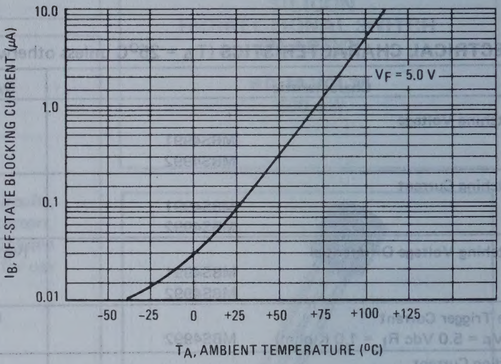


FIGURE 5 – ON-STATE VOLTAGE versus FORWARD CURRENT

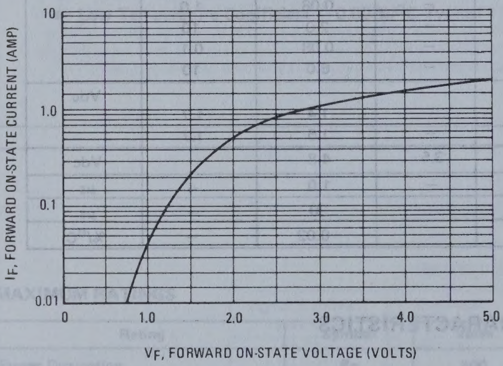


FIGURE 6 – PEAK OUTPUT VOLTAGE (FUNCTION OF R$_L$ AND C$_c$)

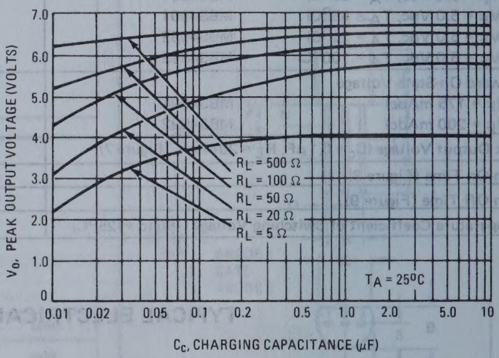


FIGURE 7 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

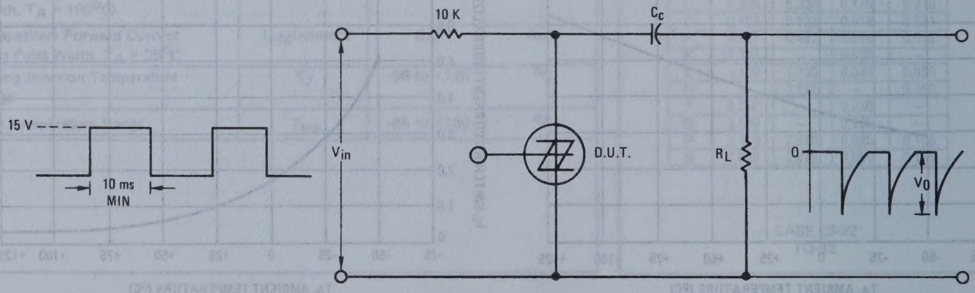
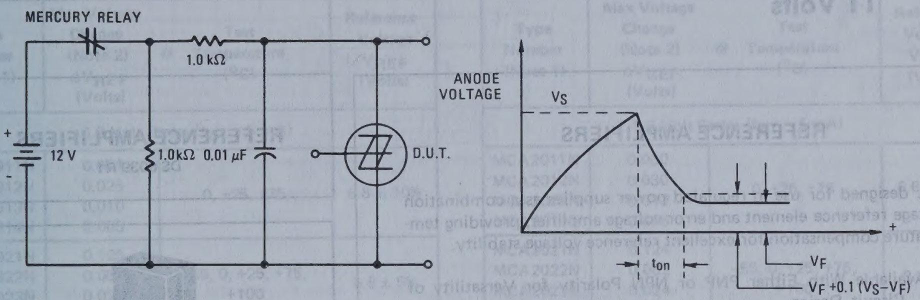
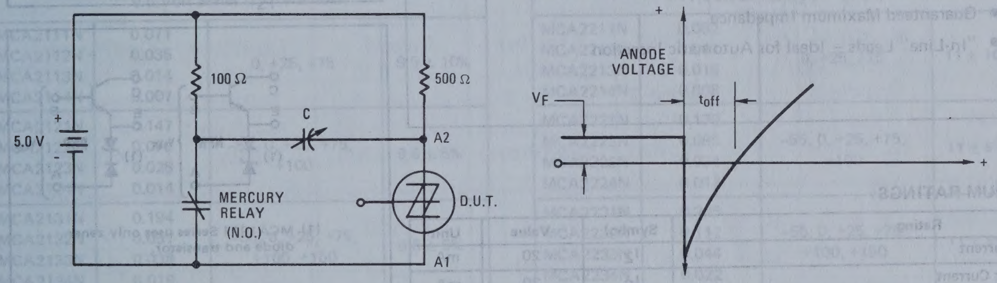

10 K
C$_c$
15 V
10 ms MIN
V$_{in}$
D.U.T.
R$_L$
0
V$_0$

FIGURE 8 – TURN-ON TIME TEST CIRCUIT


MERCURY RELAY
1.0 kΩ
+
12 V
-
1.0kΩ
0.01 μF
D.U.T.
ANODE VOLTAGE
V_S
+
t_{on}
V_F
V_F +0.1 (V_S−V_F)

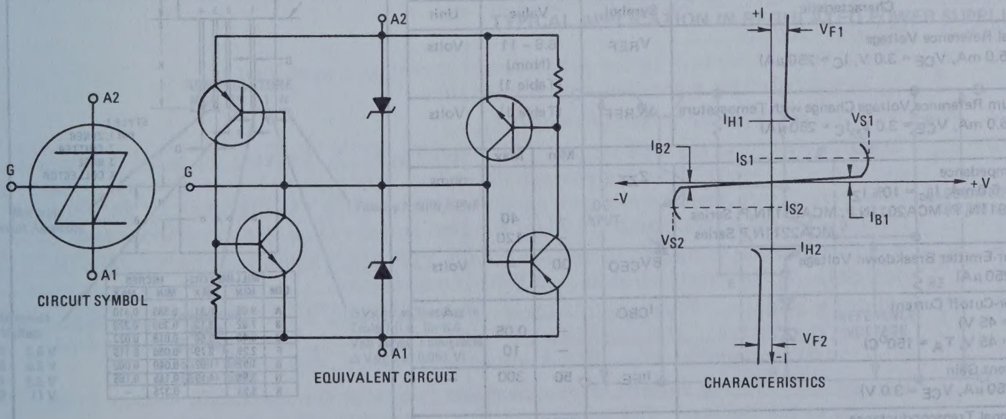
Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F.

FIGURE 9 – TURN-OFF TIME TEST CIRCUIT


+
5.0 V
-
100 Ω
500 Ω
C
A2
MERCURY RELAY (N.O.)
D.U.T.
A1
+
ANODE VOLTAGE
V_F
t_{off}
+

With the SBS in conduction and the relay contacts open, close the contacts to cause anode A2 to be driven negative. Decrease C until the SBS just remains off when anode A2 becomes positive. The turn-off time, t_{off}, is the time from initial contact closure and until anode A2 voltage reaches zero volts.

FIGURE 10 – DEVICE EQUIVALENT CIRCUIT, CHARACTERISTICS AND SYMBOLS


A2
G
A1
CIRCUIT SYMBOL
A2
G
A1
EQUIVALENT CIRCUIT
+I
V_{F1}
I_{H1}
V_{S1}
I_{B2}
I_{S1}
-V
+V
I_{S2}
I_{B1}
V_{S2}
I_{H2}
V_{F2}
-I
CHARACTERISTICS

MCA1911N, P series MCA2011N, P series (SILICON)

6.8 Volts

8.6 Volts

MCA2111N, P series

9.5 Volts

MCA2211N, P series

11 Volts

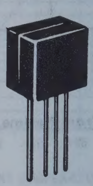
REFERENCE AMPLIFIERS

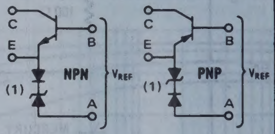
. . . designed for use in regulated power supplies as a combination voltage reference element and error voltage amplifier, providing temperature compensation for excellent reference voltage stability.

- Available With Either PNP or NPN Polarity for Versatility of Circuit Design
- Specified With a Variety of Reference Voltage Stability Factors Allowing for a Wide Selection of the Most Economical Device to Meet Circuit Requirements
- Available for Operation in Three Different Test Temperature Ranges: 0 to +75°C, -55 to +100°C, -55 to +150°C
- Guaranteed Maximum Impedance
- "In-Line" Leads – Ideal for Automatic Insertion

REFERENCE AMPLIFIERS

DS 6039 R1





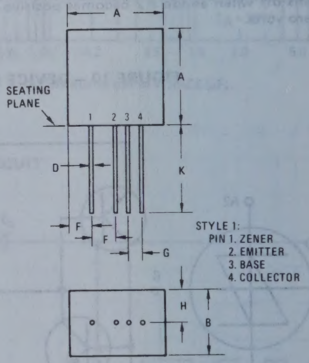
(1) MCA1911 Series uses only zener diode and transistor.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Zener Current	I_Z	20	mA
Collector Current	I_C	20	mA
Collector-Emitter Voltage	V_{CEO}	30	Volts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Value		Unit
Nominal Reference Voltage (I_Z = 5.0 mA, V_{CE} = 3.0 V, I_C = 250 μA)	V_{REF}	6.8 - 11 (Nom) (Table 1)		Volts
Maximum Reference Voltage Change with Temperature (I_Z = 5.0 mA, V_{CE} = 3.0 V, I_C = 250 μA)	ΔV_{REF}	(Table 1)		Volts
		Min	Max	
Zener Impedance (I_{ZT} = 5.0 mA, I_{ac} = 10% I_Z) MCA1911N, P; MCA2011N,P; MCA2111N,P; Series MCA2211N,P Series	Z_{ZT}	 – –	 40 120	ohms
Collector-Emitter Breakdown Voltage (I_C = 250 μA)	BV_{CEO}	30	–	Volts
Collector-Cutoff Current (V_{CB} = 45 V) (V_{CB} = 45 V, T_A = 150°C)	I_{CBO}	 – –	 0.05 10	μA
DC Current Gain (I_C = 250 μA, V_{CE} = 3.0 V)	h_{FE}	50	300	–
Small-Signal Transconductance (V_{CE} = 3.0 V, I_C = 250 μA, f = 1.0 kHz)	g_{fe}	6500	–	μmhos



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.65	10.41	0.380	0.410
B	7.62	8.13	0.300	0.320
D	0.46	0.56	0.018	0.022
F	2.29	2.79	0.090	0.110
G	1.02	1.52	0.040	0.060
H	3.68	4.19	0.145	0.165
K	9.53	–	0.375	–

CASE 212-(2)
(Formerly Case 181)

MCA1911N,P series, MCA2011N,P series, MCA2111N,P series, MCA2211N,P series (continued)

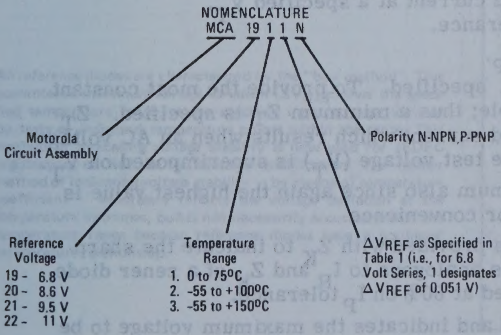
TABLE 1 – ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	@ Test Temperature (°C)	Reference Voltage V_{REF} (Volts)
6.8 Volt Series (I_{ZT} = 5 mA)			
MCA1911N MCA1912N MCA1913N MCA1914N	0.051 0.025 0.010 0.005	0, +25, +75	6.8 ± 10%
MCA1921N MCA1922N MCA1923N MCA1924N	0.105 0.052 0.020 0.010	-55, 0, +25, +75, +100	6.8 ± 5%
MCA1931N MCA1932N MCA1933N MCA1934N	0.139 0.069 0.026 0.013	-55, 0, +25, +75, +100, +150	6.8 ± 5%
9.5 Volt Series (I_{ZT} = 5 mA)			
MCA2111N MCA2112N MCA2113N MCA2114N	0.071 0.035 0.014 0.007	0, +25, +75	9.5 ± 10%
MCA2121N MCA2122N MCA2123N MCA2124N	0.147 0.073 0.028 0.014	-55, 0, +25, +75, +100	9.5 ± 5%
MCA2131N MCA2132N MCA2133N MCA2134N	0.194 0.097 0.038 0.019	-55, 0, +25, +75, +100, +150	9.5 ± 5%

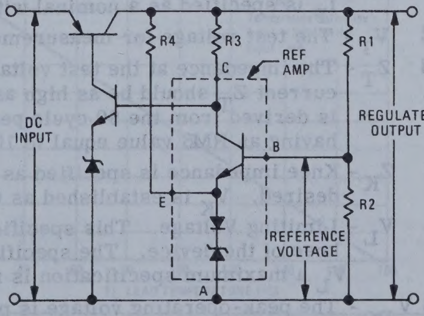
Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	@ Test Temperature (°C)	Reference Voltage V_{REF} (Volts)
8.6 Volt Series (I_{ZT} = 5 mA)			
MCA2011N MCA2012N MCA2013N MCA2014N	0.060 0.030 0.012 0.006	0, +25, +75	8.6 ± 10%
MCA2021N MCA2022N MCA2023N MCA2024N	0.124 0.062 0.024 0.012	-55, 0, +25, +75, +100	8.6 ± 5%
MCA2031N MCA2032N MCA2033N MCA2034N	0.164 0.082 0.032 0.016	-55, 0, +25, +75, +100, +150	8.6 ± 5%
11 Volt Series (I_{ZT} = 5 mA)			
MCA2211N MCA2212N MCA2213N MCA2214N	0.082 0.041 0.016 0.008	0, +25, +75	11 ± 10%
MCA2221N MCA2222N MCA2223N MCA2224N	0.170 0.085 0.034 0.017	-55, 0, +25, +75, +100	11 ± 5%
MCA2231N MCA2232N MCA2233N MCA2234N	0.225 0.112 0.044 0.022	-55, 0, +25, +75 +100, +150	11 ± 5%

NOTES:

1. Type numbers listed are NPN polarity. For PNP polarity devices substitute "P" suffix – e.g.: MCA1911N (NPN)
   MCA1911P (PNP)
2. ΔV_{REF} is the maximum voltage variation over the specified test temperature range, verified by tests at specified points within the range.

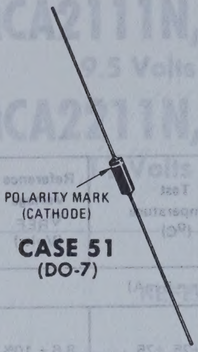

NOMENCLATURE
MCA 19 1 1 N
Motorola Circuit Assembly
Polarity N-NPN,P-PNP
Reference Voltage
19 - 6.8 V
20 - 8.6 V
21 - 9.5 V
22 - 11 V
Temperature Range
1. 0 to 75°C
2. -55 to +100°C
3. -55 to +150°C
ΔVREF as Specified in Table 1 (i.e., for 6.8 Volt Series, 1 designates ΔVREF of 0.051 V)

TYPICAL APPLICATION IN REGULATED POWER SUPPLIES


R4
R3
R1
C
REF AMP
DC INPUT
REGULATED OUTPUT
B
E
R2
REFERENCE VOLTAGE
A

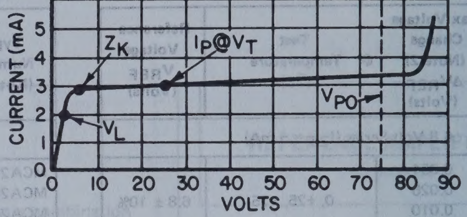
MCL1300 thru MCL1304 (SILICON)

Field-effect current limiting diodes designed for applications requiring a current reference or a constant current over a specified voltage range.



CASE 51
(DO-7)

CURRENT-LIMITER CHARACTERISTICS AND SYMBOL IDENTIFICATION
(See Notes 1 thru 6)



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Junction and Storage Temperature: -65°C to +200°C

Peak Operating Voltage: See Table

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Type Number	Nominal Pinch-Off Current Note 1 I_P (mA)	Tol. (mA)	Test Volt. Note 2 V_T (volts)	Limiter Imped. Note 3 Z_T (min) (megohms)	Knee Imped. at 6 V Note 4 Z_K (min) (megohms)	Limiting Voltage Note 5 V_L (max) (volts)	Peak Operating Voltage Note 6 V_{PO} (volts)
MCL1300	0.5	±0.3	25	4.000	0.500	1.0	75
MCL1301	1.0	±0.6	25	0.800	0.200	1.5	75
MCL1302	2.0	±0.6	25	0.400	0.100	2.0	75
MCL1303	3.0	±0.6	25	0.300	0.050	2.0	75
MCL1304	4.0	±0.6	25	0.250	0.025	2.5	75

These specifications are preliminary. Selections may be made to obtain nominal currents between those shown, as well as tighter tolerance units.

SYMBOL DEFINITIONS:

Note 1 I_P - The pinch-off current is the guaranteed current at a specified V_T. I_P is specified as a nominal with a tolerance.

Note 2 V_T - The test voltage for measurement of I_P.

Note 3 Z_T - The impedance at the test voltage, V_T, specified. To provide the most constant current Z_T should be as high as possible; thus a minimum Z_T is specified. Z_T is derived from the 90 cycle per second current which results when an AC voltage having an RMS value equal to 10% of the test voltage (V_T) is superimposed on V_T.

Note 4 Z_K - Knee impedance is specified as a minimum also since again the highest value is desired. V_K is established as 6.0 V for convenience.

Note 5 V_L - Limiting Voltage. This specification is provided with Z_K to indicate the sharp knee of the device. The specification is analogous to I_R and Z_K of a zener diode. V_L a maximum specification is measured at 80% on I_P tolerance.

Note 6 V_{PO} - The peak-operating voltage is provided and indicates the maximum voltage to be applied to the device. The specification is necessary since the device is either power limited or breakdown limited beyond this specified voltage.

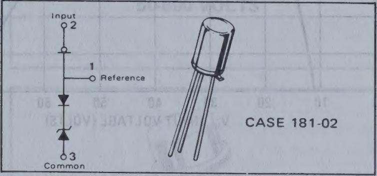
MCLTC6010
MCLTC6025
MCLTC6050
MCLTC6100

CURRENT LIMITED TEMPERATURE COMPENSATED VOLTAGE REFERENCE DIODES

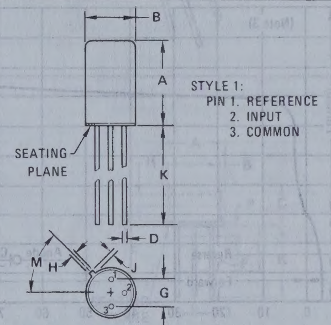
Voltage reference element with inherent temperature compensation and current regulation resulting in excellent reference stability over temperature excursions and wide variations of input voltage.

- Available in a Wide Range of Temperature Compensation to Allow for Economical Circuit Design
- Peak Operating Voltage — V_{in} = 75 Volts
- Variations in Input Current, Peak operating voltages and compensation temperature range are available upon request.

CURRENT LIMITED VOLTAGE REFERENCE DIODES



CASE 181-02



STYLE 1:
PIN 1. REFERENCE
2. INPUT
3. COMMON

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	17.02	–	0.670
B	9.14	9.78	0.360	0.385
D	0.41	0.48	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.71	0.86	0.028	0.034
J	0.51	–	0.020	–
K	38.10	–	1.500	–
M	42^{0}	48^{0}	42^{0}	48^{0}

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage	V_{in}	75	Volts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	^{o}C
DC Power Dissipation L = 3/8″, T_L = 25^{o}C Derate above T_L = 25^{o}C	P_D	180 1.2	mW mW/^{o}C

ELECTRICAL CHARACTERISTICS (T_L = 25^{o}C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Reference Voltage (V_{in} = 31 Volts)	V_{REF}	6.08	6.72	Volts
Input Voltage	V_{in}	12	75	Volts
Input Current (V_{in} = 31 Volts)	I_{in}	3.2	4.8	mA
Input Impedance	—	0.2	—	MOhms
Zener Impedance (I_{in} = 4.0 mA)	Z_{REF}	—	50	Ohms
Voltage Reference Change (1) (V_{in} = 31 Volts) -55^{o}C, +25^{o}C, +100^{o}C	ΔV_{REF}			Volts
MCLTC6010		—	0.010	
MCLTC6025		—	0.025	
MCLTC6050		—	0.050	
MCLTC6100		—	0.100	

(1) All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_{REF}) over the specified temperature range, at the specified input voltage, verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship.

FIGURE 1 – POWER DERATING

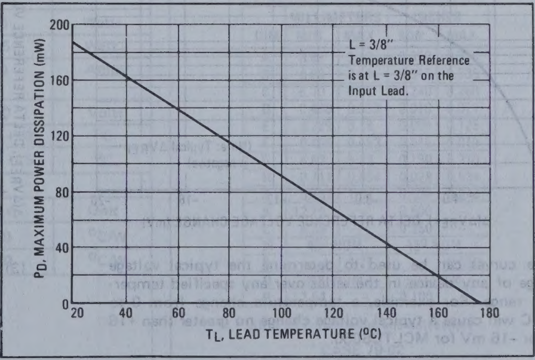


FIGURE 2 – EFFECTS OF INPUT VOLTAGE ON REFERENCE VOLTAGE

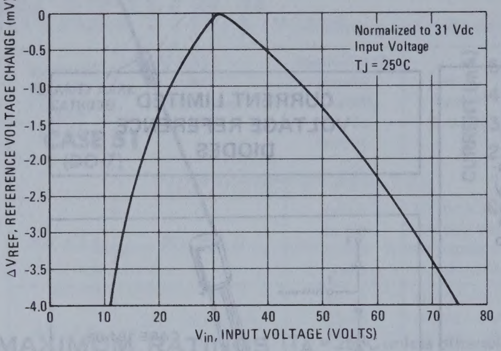


FIGURE 3 – EFFECTS OF TEMPERATURE ON REFERENCE VOLTAGE

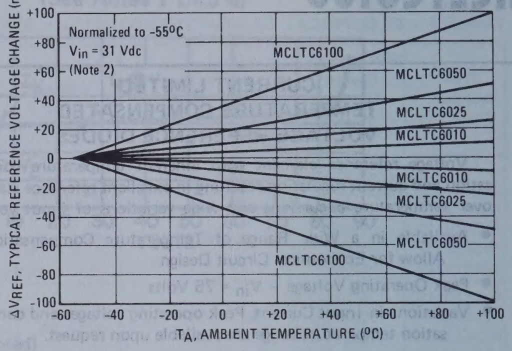


FIGURE 4 – TYPICAL CURRENT REGULATING CHARACTERISTICS (Current Regulator Only)

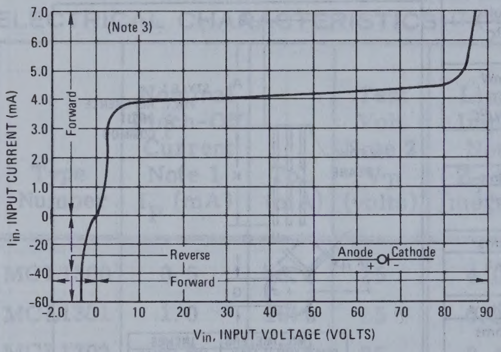


FIGURE 5 – EFFECTS OF LOAD RESISTANCE ON REFERENCE VOLTAGE

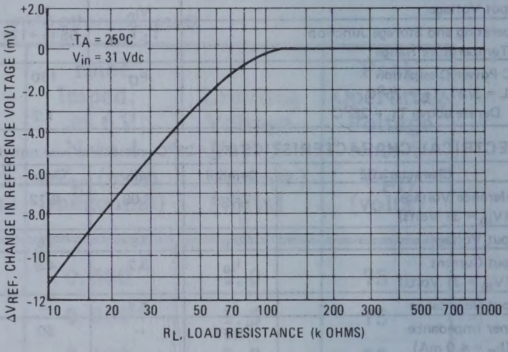


FIGURE 6 – EFFECTS OF LOAD CURRENT ON ΔV_{REF}

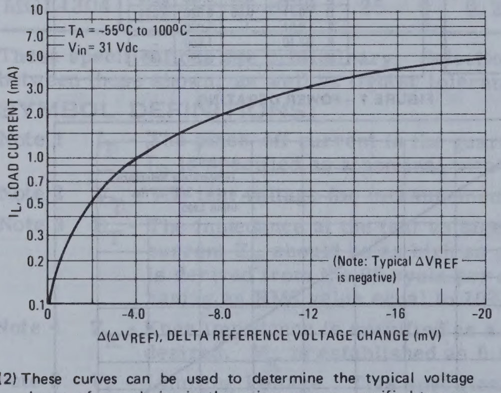
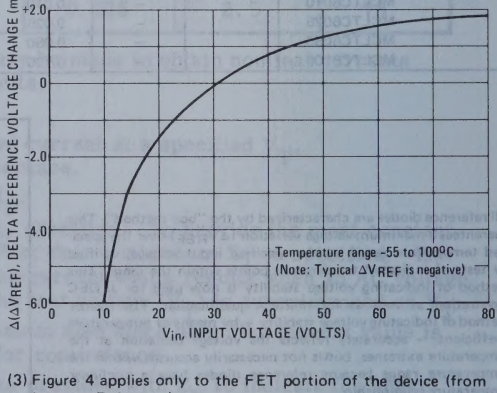


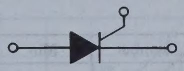
FIGURE 7 – EFFECTS OF INPUT VOLTAGE ON ΔV_{REF}



(2) These curves can be used to determine the typical voltage change of any device in the series over any specified temperature range. For example, a temperature change from 0 to +50°C will cause a typical voltage change no greater than +16 mV or -16 mV for MCLTC6050.

(3) Figure 4 applies only to the FET portion of the device (from Input to Reference).

MCR32 SERIES (SILICON)



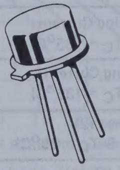
THYRISTORS

7 AMPERES RMS
50-600 VOLTS

SILICON CONTROLLED RECTIFIERS

. . . designed primarily for industrial applications. Ideally suited for capacitor-discharge ignition, systems, power switching and power control.

- Glass Passivated for High Reliability
- Low Profile Hermetic Package for Tight Printed Circuit Board Applications
- High di/dt Capability

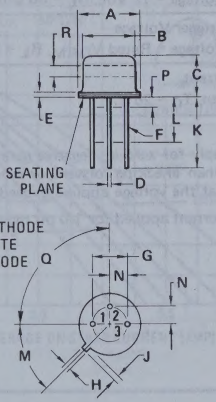


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR32- -05 20 30 40 50 60	V_{RRM}	 50 200 300 400 500 600	Volts
Forward Current RMS (See Figures 4 & 5) (All Conduction Angles)	$I_{T(RMS)}$	7.0	Amps
Peak Forward Surge Current, $T_A = 25^oC$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	80	Amps
Circuit Fusing Considerations, $T_A = 25^oC$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Forward Peak Gate Power, $T_A = 25^oC$	P_{GM}	10	Watts
Forward Average Gate Power, $T_A = 25^oC$	$P_{GF(AV)}$	0.5	Watt
Forward Peak Gate Current, $T_A = 25^oC$ (300 μs, 120 PPS)	I_{GFM}	10	Amps
Reverse Peak Gate Voltage	V_{GRM}	4.0	Volts
Operating Junction Temperature Range	T_J	-40 to +135	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	$^oC/W$



STYLE 3
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (1) MCR32-05 MCR32-20 MCR32-30 MCR32-40 MCR32-50 MCR32-60	V_{DRM}	 50 200 300 400 500 600	 – – – – – –	Volts
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 135°C)	I_{DRM}	–	1.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 135°C)	I_{RRM}	–	1.0	mA
Forward "On" Voltage (2) (I_{TM} = 30 A peak @ T_C = 25°C)	V_{TM}	–	2.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)	I_{GT}	–	20	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)	V_{GT}	–	1.5	Volts
Gate Non-Trigger Voltage (Anode Voltage = Rated V_{DRM}, R_L = 30 Ohms, T_C = 135°C)	V_{GD}	0.1	–	Volts
Holding Current (Gate Open, T_C = 25°C)	I_H	–	20	mA

(1) Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.

(2) Forward current applied for 1.0 ms maximum duration, duty cycle ≤1.0%.

FIGURE 1 – TYPICAL PULSE TRIGGER CURRENT

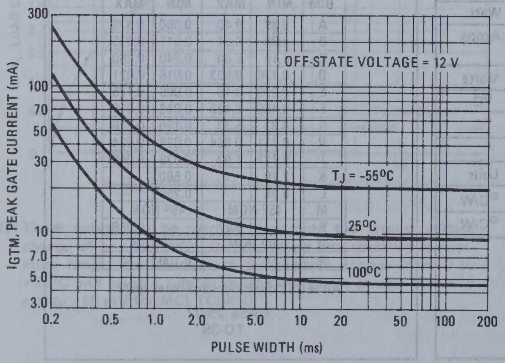


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

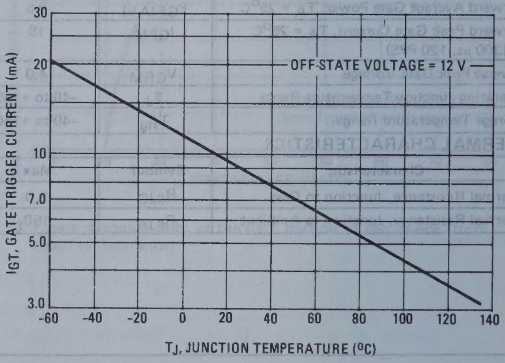


FIGURE 3 – MAXIMUM ON-STATE POWER DISSIPATION

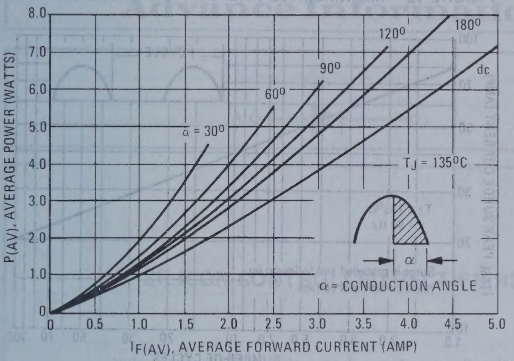


FIGURE 4 – AVERAGE CURRENT DERATING (REFERENCE. CASE TEMPERATURE)

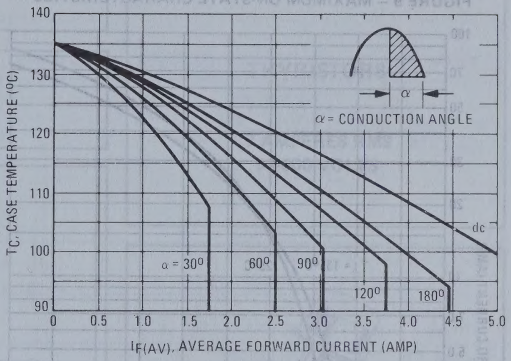


FIGURE 5 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE 4 in. sq. P.C. BOARD)

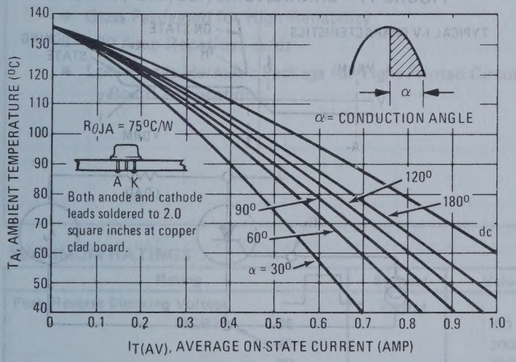


FIGURE 6 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE , TYPICAL P.C. BOARD MOUNTING)

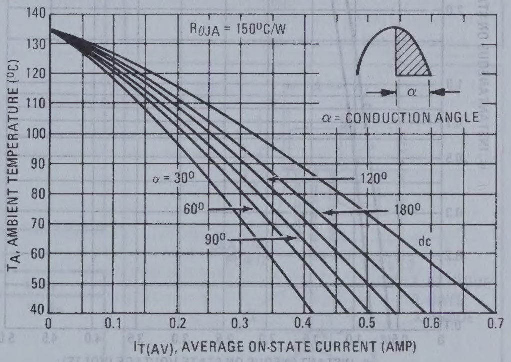


FIGURE 7 – TYPICAL GATE TRIGGER VOLTAGE

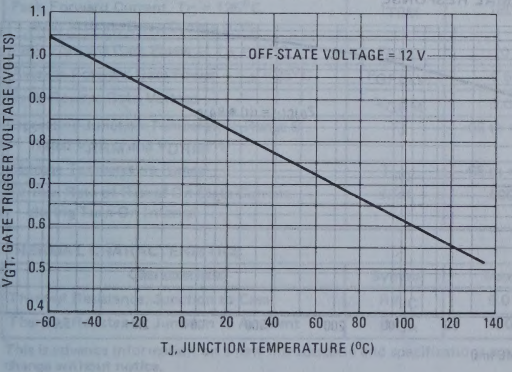


FIGURE 8 – TYPICAL HOLDING CURRENT

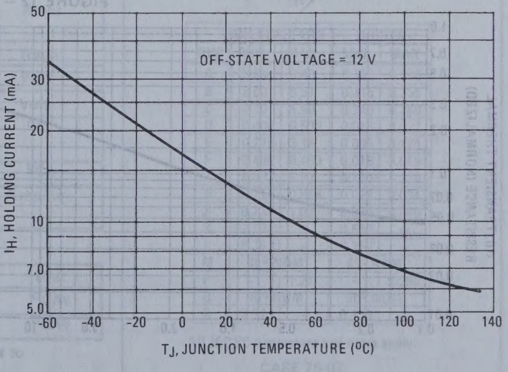


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

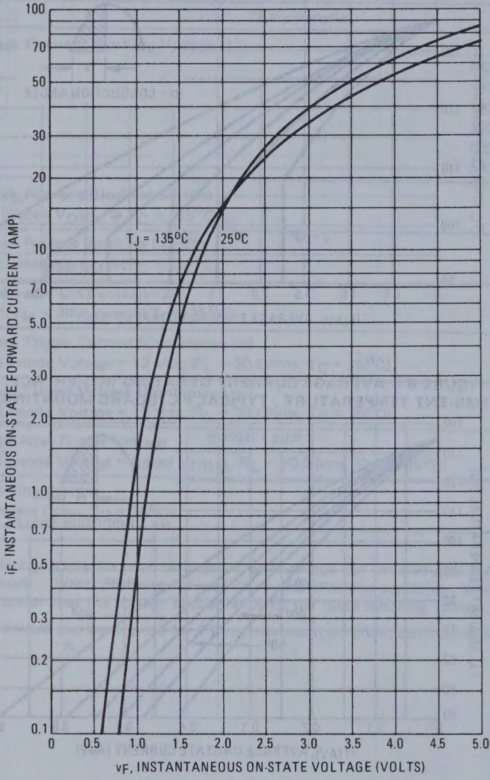


FIGURE 10 – MAXIMUM NON-REPETITIVE SURGE CURRENT

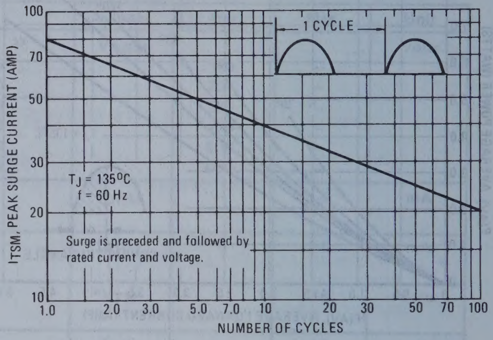


FIGURE 11 – CHARACTERISTICS AND SYMBOLS

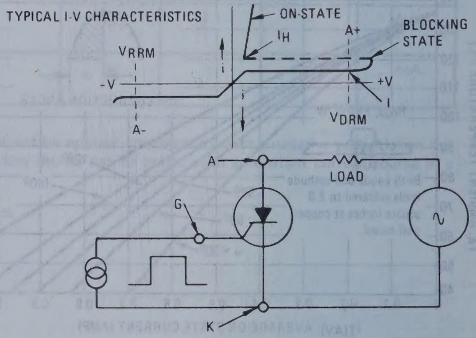
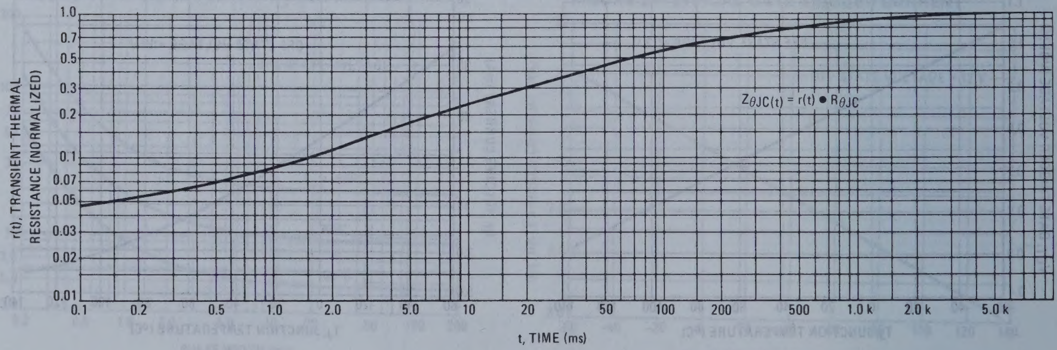
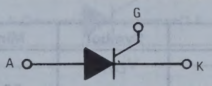

TYPICAL I-V CHARACTERISTICS
ON-STATE
I_H
A+
BLOCKING STATE
V_{RRM}
-V
+V
i
I
V_{DRM}
A-
A
LOAD
G
K

FIGURE 12 – THERMAL RESPONSE



MCR39 SERIES (SILICON)

Advance Information



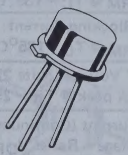
SILICON CONTROLLED RECTIFIERS

. . . designed for CD ignition and crowbar applications requiring high repetitive di/dt.

- Glass Passivated for High Reliability
- 180 Amp Repetitive di/dt
- Low Profile Hermetic Package for Tight Printed Circuit Board Applications.

THYRISTORS

7 AMPERES RMS
50-600 VOLTS



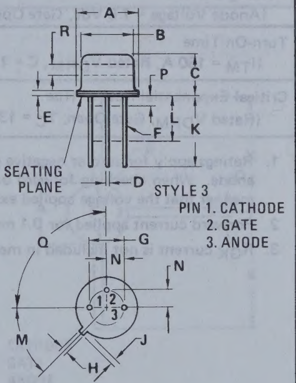
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR39- -05 -20 -30 -40 -50 -60	V_{RRM}	 50 200 300 400 500 600	Volts
Peak Forward Current, $T_C = 125^oC$ P.W. = 10 μs, Duty Cycle = 0.1%	I_{TSM}	180	Amps
Peak Forward Gate Power – $T_A = 25^oC$	P_{GFM}	10	Watts
Average Forward Gate Power – $T_A = 25^oC$	$P_{GF(AV)}$	0.5	Watt
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}(1)	T_J	-65 to +135	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC
Critical Rate-of-Rise of On-State Current during Turn-On Interval	di/dt	500	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	5.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	150	$^oC/W$

This is advance information on a new introduction and specifications are subject to change without notice.



STYLE 3
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) (T_C = 135°C)	V_{DRM}			Volts
MCR39-05		50	–	
MCR39-20		200	–	
MCR39-30		300	–	
MCR39-40		400	–	
MCR39-50		500	–	
MCR39-60		600	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 135°C)	I_{DRM}	–	2.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 135°C)	I_{RRM}	–	2.0	mA
Forward "On" Voltage (Note 2) (I_{TM} = 50 A peak @ T_A = 25°C)	V_{TM}	–	3.5	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = Rated V_{DRM}) T_C = 25°C	I_{GT}	1.0	15	mA
T_C = −40°C		–	30	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = Rated V_{DRM}) T_C = 25°C	V_{GT}	0.25	1.25	Volts
T_C = −40°C		–	1.5	
Holding Current (Anode Voltage = 7.0 Vdc, Gate Open, T_C = 135°C)	I_H	1.0	–	mA
Turn-On Time (I_{TM} = 180 A, Rated V_{DRM}, C = 1.0 μF, 10 to 90%)	t_{on}	–	500	ns
Critical Exponential Rate of Rise (Rated V_{DRM}, Gate Open, T_C = 135°C)	dv/dt	50	–	V/μs

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 0.1 ms maximum duration, duty cycle ≤ 0.1%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – TYPICAL PULSE TRIGGER CURRENT

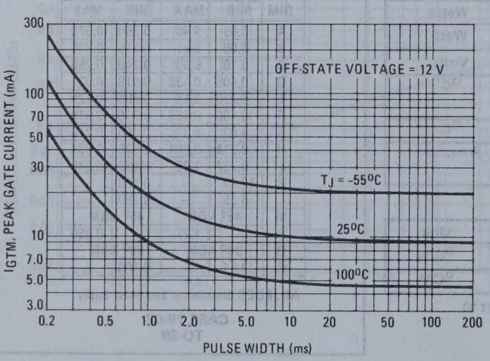
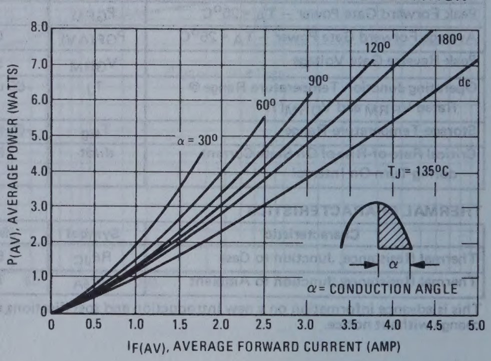
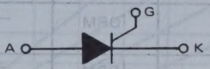


FIGURE 2 – MAXIMUM ON-STATE POWER DISSIPATION

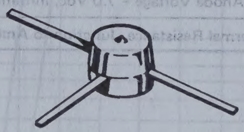


MCR051 (SILICON)
thru
MCR054



MICRO-T PLASTIC SILICON CONTROLLED RECTIFIERS

0.25 AMPERE RMS
15 thru 100 VOLTS



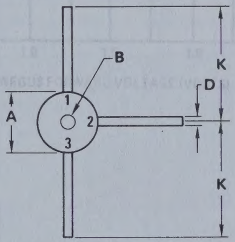
PLASTIC THYRISTORS

. . . Annular PNPN devices designed for applications such as relay and lamp drivers, small motor controls, gate drivers for larger thyristors, and sensing and detection circuits.

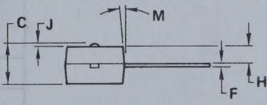
- Sensitive Gate Trigger Current — 200 µA Maximum
- Low Reverse and Forward Blocking Current — 50 µA Maximum, $T_A = 125^oC$
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity
- Small Size for High Density Packaging

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR051 MCR052 MCR053 MCR054	V_{RRM}	 15 30 60 100	Volts
Forward Current RMS (See Figure 3) (All Conduction Angles)	$I_{T(RMS)}$	0.25	Amp
Peak Forward Surge Current, $T_A = 25^oC$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, $T_A = 25^oC$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, $T_A = 25^oC$	P_{GM}	0.1	Watt
Average Gate Power — Forward, $T_A = 25^oC$	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward, $T_A = 25^oC$ (300 µs, 120 PPS)	I_{GFM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GRM}	4.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}	T_J	-65 to +125	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC
Lead Solder Temperature (<1/16" from case, 10 s max)	—	+230	^oC



STYLE 8:
PIN 1. CATHODE
2. GATE
3. ANODE



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic			Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)			V_{DRM}			Volts
(T_A = 125°C)	MCR051			15	–	
	MCR052			30	–	
	MCR053			60	–	
	MCR054			100	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_A = 125°C)			I_{DRM}	–	50	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_A = 125°C)			I_{RRM}	–	50	μA
Forward "On" Voltage (Note 2) (I_{TM} = 0.25 A peak @ T_A = 25°C)			V_{TM}	–	1.3	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		T_C = 25°C	I_{GT}	–	200	μA
Gate Trigger Voltage (Continuous dc)		T_C = 25°C	V_{GT}	–	0.8	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		T_C = -65°C		–	1.2	
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms)		T_C = 125°C	V_{GD}	0.1		
Holding Current		T_C = 25°C	I_H	–	5.0	mA
(Anode Voltage = 7.0 Vdc, initiating current = 20 mA)		T_C = -65°C		–	10*	
Thermal Resistance, Junction to Ambient			θ_{JA}	–	500	°C/W

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – POWER DISSIPATION

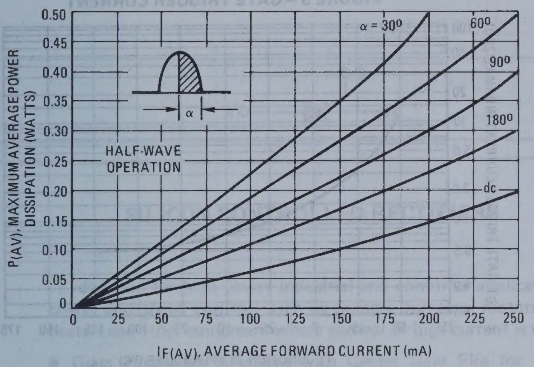


FIGURE 2 – FORWARD VOLTAGE

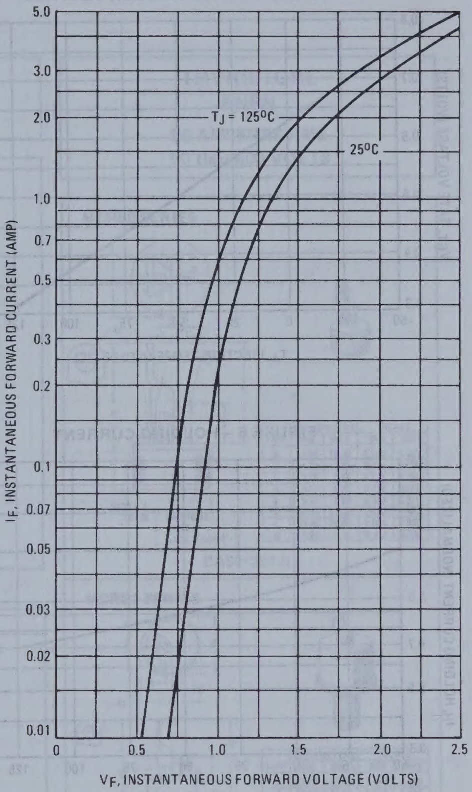
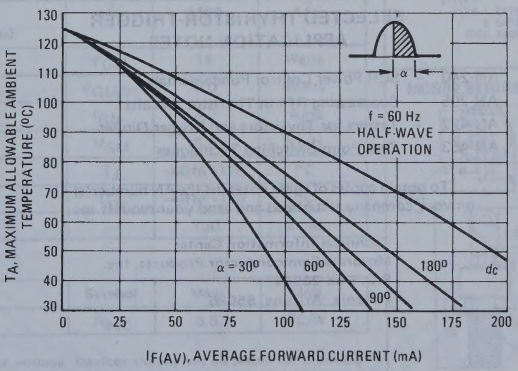


FIGURE 3 – CURRENT DERATING



TYPICAL CHARACTERISTICS

FIGURE 4 – GATE TRIGGER VOLTAGE

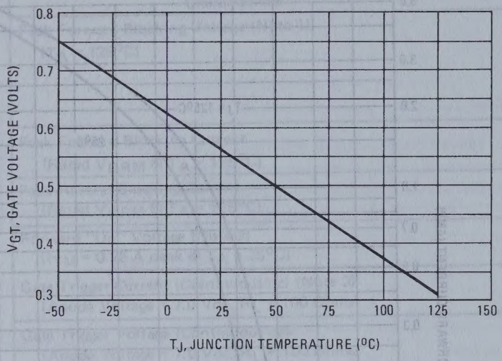


FIGURE 5 – GATE TRIGGER CURRENT

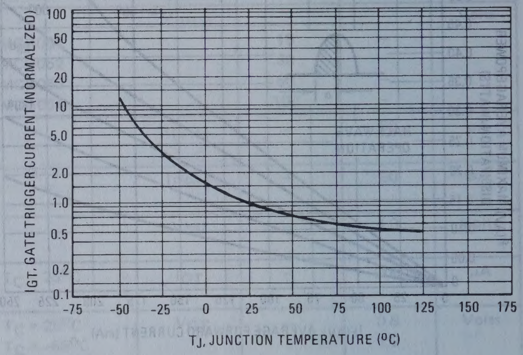


FIGURE 6 – HOLDING CURRENT

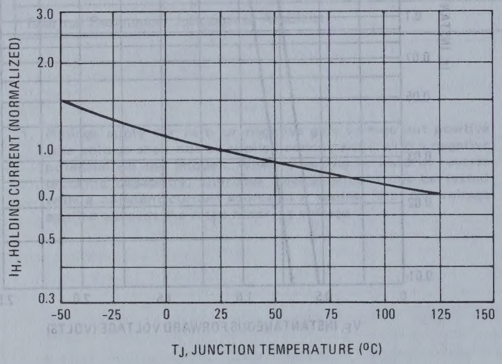
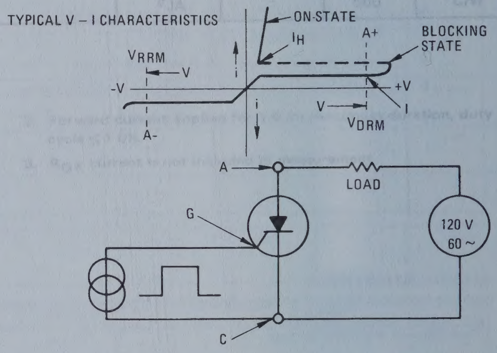


FIGURE 7 – CHARACTERISTICS AND SYMBOLS


TYPICAL V – I CHARACTERISTICS
ON-STATE
I_H
A+
BLOCKING STATE
V_RRM
-V
V
i
+V
V
I
V_DRM
i
A-
A
LOAD
G
120 V
60 ~
C

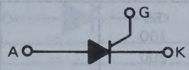
SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-240	— SCR Power Control Fundamentals
AN-295	— Suppressing RFI in Thyristor Circuits
AN-422	— Testers for Thyristors and Trigger Diodes
AN-453	— Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

MCR80 series (SILICON)
MCR81 series
MCR82 series



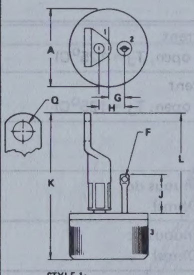
SILICON CONTROLLED RECTIFIERS

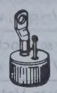
. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed.

- Glass Passivated Junctions with Center Gate Fire for Greater Parameter Uniformity and Stability.
- All Devices are Hermetically Sealed
- Epoxy Encapsulated for Long Voltage Creepage Path
- MCR82 Series Internally Isolated with 5000 Volt Dielectric Strength
- Flexible Leads are Optional – Consult Factory

THYRISTORS
PNPN
80 AMPERES RMS
50 thru 800 VOLTS

MCR80 SERIES



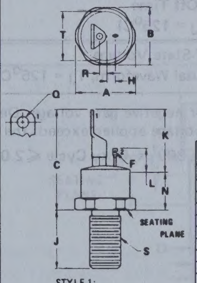


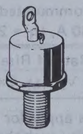
STYLE 1:
TERM. 1. CATHODE
2. GATE
3. CASE, ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	19.05	19.30	0.750	0.760
F	1.27	1.65	0.050	0.065
G	3.68	3.94	0.145	0.155
H	5.97	6.22	0.235	0.245
J	9.27	9.53	0.365	0.375
K	36.20	37.47	1.425	1.475
L	25.40	26.67	1.000	1.050
Q	4.83	5.21	0.190	0.205

CASE 287-01

MCR81 SERIES



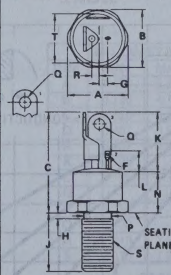


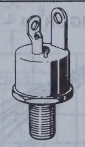
STYLE 1:
TERM. 1. CATHODE
2. GATE
STUD. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	29.72	30.23	1.170	1.190
B	26.42	27.05	1.040	1.065
C	40.64	43.18	1.600	1.700
F	1.27	1.65	0.050	0.065
H	3.68	3.94	0.145	0.155
J	21.59	22.48	0.850	0.885
K	22.86	27.94	0.900	1.100
L	5.08	9.53	0.200	0.375
N	17.15	20.96	0.675	0.825
Q	4.83	5.21	0.190	0.205
R	2.16	2.41	0.085	0.095
S	1/2 – 20 UNF – 2A			
T	25.27	25.78	0.995	1.015

CASE 288-01

MCR82 SERIES





STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE
STUD. ISOLATED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	29.72	30.23	1.170	1.190
B	26.42	27.05	1.040	1.065
C	45.72	48.26	1.800	1.900
F	1.27	1.65	0.050	0.065
G	3.68	3.94	0.145	0.155
H	2.29	2.79	0.090	0.110
J	21.59	22.48	0.850	0.885
K	22.86	27.94	0.900	1.100
L	5.08	9.53	0.200	0.375
N	22.10	23.11	0.870	0.910
P	11.43	11.94	0.450	0.470
Q	4.83	5.21	0.190	0.205
R	2.16	2.41	0.085	0.095
S	1/2 – 20 UNF – 2A			
T	25.27	25.78	0.995	1.015

CASE 291-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage MCR80- MCR81- MCR82-	V_{RRM}(1)		Volts
-0.5		50	
-10		100	
-20		200	
-30		300	
-40		400	
-50		500	
-60		600	
-70		700	
-80		800	
Average On-State Current ($T_C = 75^oC$)	$I_{T(AV)}$	50	Amp
Peak Non-Repetitive Surge Current (One Cycle, 60 Hz) ($T_C = 75^oC$)	I_{TSM}	1000	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C) (t = 1.5 to 8.3 ms)	I^2t	4150	A^2s
Peak Gate Power	P_{GM}	15	Watts
Average Gate Power	$P_{G(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (3)	—	130	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.6	°C/W

(1) Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.

(2) Devices should not be operated with a positive bias applied to the gate concurrent with a negative potential applied to the anode.

(3) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or seal broken.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (1) (T_J = 125°C) MCR80- MCR81- MCR82- -0.5 -10 -20 -30 -40 -50 -60 -70 -80	V_{DRM}	50 100 200 300 400 500 600 700 800	– – – – – – – – –	– – – – – – – – –	Volts
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	4.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	4.0	mA
Peak On-State Voltage (2) (I_{TM} = 160 A Peak)	V_{TM}	–	–	1.55	Volts
Gate Trigger Current, Continuous dc (V_{AK} = 12 V, R_L = 3.0 Ohms)	I_{GT}	–	–	70	mA
Gate Trigger Voltage, Continuous dc (V_{AK} = 12 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (V_{AK} = 12 V, Gate Open)	I_H	–	–	70	mA
Non-Trigger Gate Voltage (Anode Voltage = Rated V_{DM}, R_L = 100 ohms, T_J = 125°C)	V_{GD}	0.25	–	–	Volts
Circuit Commutated Turn-Off Time (I_T = 50 A, I_R = 20 A, T_J = 125°C)	t_q	–	70	–	μs
Critical Rate of Rise of Off-State Voltage (Rated V_{DRM}, Exponential Waveform, T_J = 125°C, Gate Open)	dv/dt	–	100	–	V/μs

(1) Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 – AVERAGE CURRENT DERATING

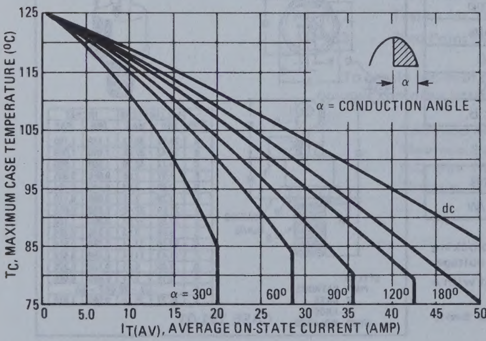
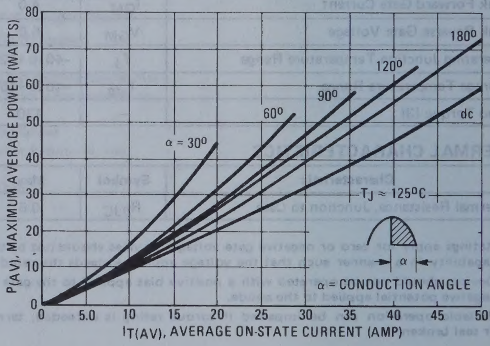
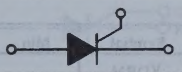


FIGURE 2 – ON-STATE POWER DISSIPATION



MCR101 (SILICON)
thru
MCR104



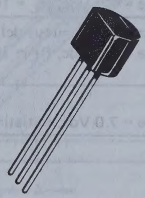
PLASTIC THYRISTORS

. . . Annular PNPN devices designed for low cost, high volume consumer applications such as relay and lamp drivers, small motor controls, gate drivers for larger thyristors, and sensing and detection circuits. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Sensitive Gate Trigger Current — 200 μA Maximum
- Low Reverse and Forward Blocking Current — 100 μA Maximum, $T_C = 85^oC$
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity

PLASTIC SILICON CONTROLLED RECTIFIERS

0.8 AMPERE RMS
15 thru 100 VOLTS



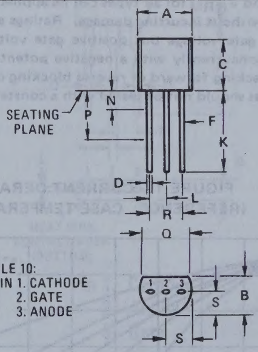
MAXIMUM RATINGS(1)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage	V_{RRM}		Volts
MCR101		15	
MCR102		30	
MCR103		60	
MCR104		100	
Forward Current RMS (See Figures 1 & 2) (All Conduction Angles)	$I_{T(RMS)}$	0.8	Amp
Peak Forward Surge Current, $T_A = 25^oC$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, $T_A = 25^oC$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, $T_A = 25^oC$	P_{GM}	0.1	Watt
Average Gate Power — Forward, $T_A = 25^oC$	$P_{G(AV)}$	0.01	Watt
Peak Gate Current — Forward, $T_A = 25^oC$ (300 μs, 120 PPS)	I_{GM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GM}	4.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}	T_J	-65 to +85	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC
Lead Solder Temperature (<1/16″ from case, 10 s max)	—	+230	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	75	$^oC/W$
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$	200	$^oC/W$

(1) Temperature reference point for all case temperature is center of flat portion of package.
($T_C = +85^oC$ unless otherwise noted.)



STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) (T_C = 85°C)		V_{DRM}			Volts
	MCR101		15	–	
	MCR102		30	–	
	MCR103		60	–	
	MCR104		100	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 85°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 85°C)		I_{RRM}	–	100	μA
Forward "On" Voltage (Note 2) (I_{TM} = 1.0 A peak @ T_A = 25°C)		V_{TM}	–	1.7	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	I_{GT}	–	200	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	V_{GT}	–	0.8	Volts
	T_C = -65°C		–	1.2	
	T_C = 85°C	V_{GD}	0.1	–	
Holding Current (Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = 25°C	I_H	–	5.0	mA
	T_C = -65°C		–	10	

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

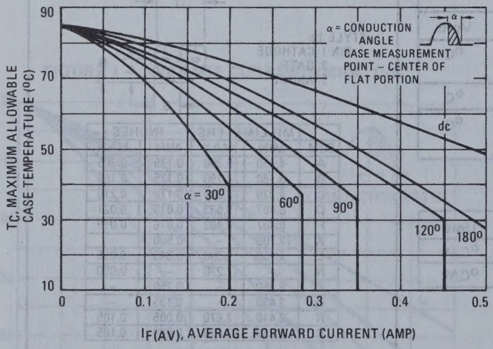
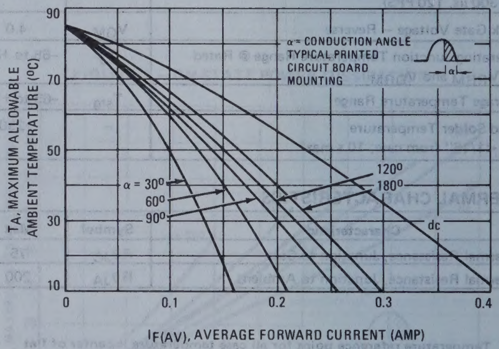
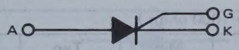


FIGURE 2 – CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)



MCR106-1 (SILICON)
thru
MCR106-4
MCR106-6, MCR106-8



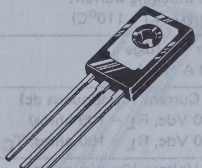
SILICON CONTROLLED RECTIFIERS

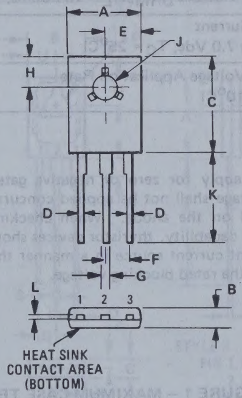
. . . Annular PNPN devices designed for high volume consumer applications such as temperature, light, and speed control; process and remote control, and warning systems where reliability of operation is important.

- Annular Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability.

THYRISTORS

4.0 AMPERES RMS
30 thru 600 VOLTS





Pin 1. Cathode
2. Anode
3. Gate

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.860	8.380	0.270	0.330
B	1.770	3.300	0.070	0.130
C	9.910	11.430	0.390	0.450
D	0.508	0.660	0.020	0.026
E	3.810 NOM		0.150 NOM	
F	2.290 TP		0.090 TP	
G	0.635	0.889	0.025	0.035
H	3.300	4.450	0.130	0.175
J	2.910	3.000	0.115	0.118
K	15.110	16.650	0.595	0.655
L	0.381	0.635	0.015	0.025

CASE 77-02

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) MCR106-1 -2 -3 -4 -6 -8	V_{RRM}	 30 60 100 200 400 600	Volts
RMS Forward Current (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Average Forward Current $T_C = 93^oC$ $T_A = 30^oC$	$I_{T(AV)}$	 2.55 0.68	Amp
Peak Non-Repetitive Surge Current (1/2 cycle, 60 Hz, $T_J = -40$ to $+110^oC$)	I_{TSM}	25	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+110^oC$, t = 1.0 to 8.3 ms)	I^2t	2.6	A^2s
Peak Gate Power	P_{GM}	0.5	Watt
Average Gate Power	$P_{G(AV)}$	0.1	Watt
Peak Forward Gate Current	I_{GM}	0.2	Amp
Peak Reverse Gate Voltage	V_{RGM}	6.0	Volts
Operating Junction Temperature Range	T_J	-40 to +110	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC
Mounting Torque (Note 2)	–	6.0	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	75	$^oC/W$

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms.)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C, Note 1)	MCR106-1 -2 -3 -4 -6 -8	V_{DRM}	30 60 100 200 400 600	– – – – – –	– – – – – –	Volts
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 110°C)		I_{DRM}	–	–	200	µA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 110°C)		I_{RRM}	–	–	200	µA
Forward "On" Voltage (I_{TM} = 4.0 A Peak)		V_{TM}	–	–	2.0	Volts
Gate Trigger Current (Continuous dc) (V_{AK} = 7.0 Vdc, R_L = 100 ohms) (V_{AK} = 7.0 Vdc, R_L = 100 ohms, T_C = –40°C)		I_{GT}	 – –	 – –	 200 500	µA
Gate Trigger Voltage (Continuous dc) (V_{AK} = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)		V_{GT}	–	–	1.0	Volts
Gate Non-Trigger Voltage (V_{AK} = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C)		V_{GD}	0.2	–	–	Volts
Holding Current (V_{AK} = 7.0 Vdc, T_C = 25°C)		I_H	–	–	5.0	mA
Forward Voltage Application Rate (T_J = 110°C)		dv/dt	–	10	–	V/µs

NOTES:

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19523 or equivalent). Mounting torque in excess of 6 in. lb. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common. (See AN-290 B)

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

CURRENT DERATING

FIGURE 1 — MAXIMUM CASE TEMPERATURE

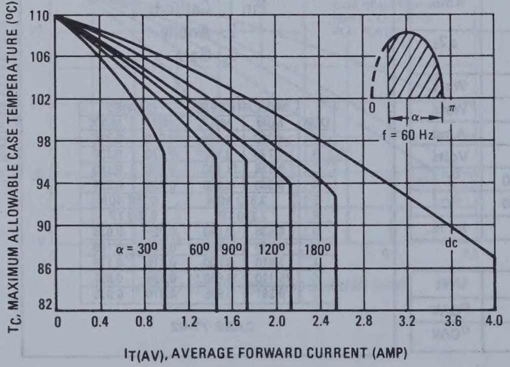
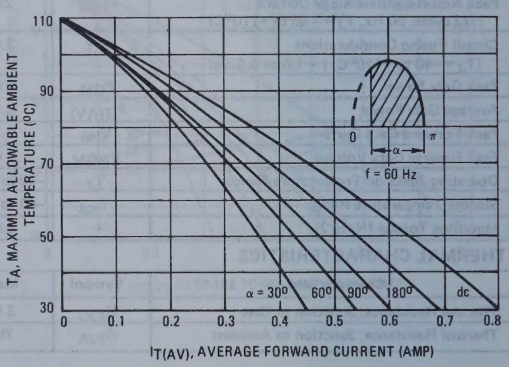
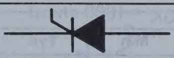


FIGURE 2 — MAXIMUM AMBIENT TEMPERATURE



MCR107-1 thru MCR107-8 (SILICON)



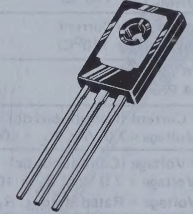
PLASTIC SILICON CONTROLLED RECTIFIERS

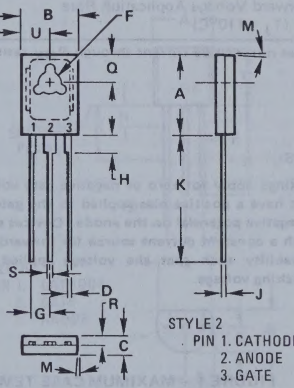
4.0 AMPERES RMS
30 thru 600 VOLTS

PLASTIC THYRISTORS
(PLASTIC SILICON CONTROLLED RECTIFIERS)

. . . Annular PNPN devices designed for high volume consumer applications such as temperature, light, and speed control; process and remote control, and warning systems where reliability of operation is important.

- Annular Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction for Low Thermal Resistance, High Heat Dissipation and Durability





STYLE 2
PIN 1. CATHODE
2. ANODE
3. GATE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) MCR107-1 -2 -3 -4 -5 -6 -7 -8	V_{RRM}	30 60 100 200 300 400 500 600	Volts
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Peak Forward Surge Current (½ cycle, 60 Hz, $T_J = -40$ to $+110^{o}C$)	I_{TSM}	25	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+110^{o}C$) t = 1.0 to 8.3 ms)	I^2t	2.6	A^2s
Peak Gate Power - Forward	P_{GFM}	0.5	Watt
Average Gate Power - Forward	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current - Forward	I_{GFM}	0.2	Amp
Peak Gate Voltage - Reverse	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	−40 to +110	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Mounting Torque (4-40) (Note 2)	—	8.0	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.0	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	75	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristics	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) (Note 1) MCR107-1	V_{DRM}	30	–	–	Volts
-2		60	–	–	
-3		100	–	–	
-4		200	–	–	
-5		300	–	–	
-6		400	–	–	
-7		500	–	–	
-8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 110°C)	I_{DRM}	–	–	200	µA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 110°C)	I_{RRM}	–	–	200	µA
Forward "On" Voltage (I_{TM} = 4.0 A Peak)	V_{TM}	–	–	2.0	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)	I_{GT}	–	–	20	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)	V_{GT}	–	–	1.5	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C)	V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc, T_C = 25°C)	I_H	–	–	20	mA
Forward Voltage Application Rate (T_J = 110°C)	dv/dt	–	10	–	V/µs

(1) Does not include current through R_{GK} resistor.

NOTES:

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) Torque rating applies with use of torque washer (Shakeproof WD19523 or equivalent). Mounting torque in excess of 6 in. lb. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.
For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C.

CURRENT DERATING DATA

FIGURE 1 – MAXIMUM CASE TEMPERATURE

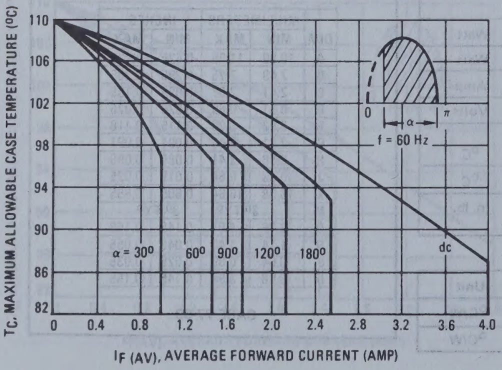
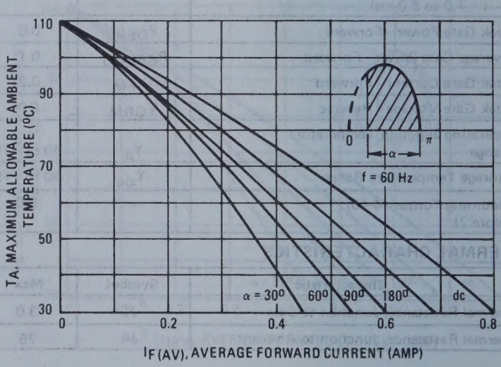
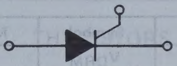


FIGURE 2 – MAXIMUM AMBIENT TEMPERATURE



MCR115 (SILICON)
MCR120



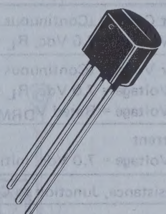
PLASTIC THYRISTORS

. . . Annular PNPN devices designed for high volume consumer applications such as relay and lamp drivers, small motor controls, gate drivers for larger thyristors, and sensing and detection circuits. Supplied in an inexpensive plastic TO-92 package which is readily adaptable for use in automatic insertion equipment.

- Sensitive Gate Trigger Current — 200 µA Maximum
- Low Reverse and Forward Blocking Current — 100 µA Maximum, $T_C = 110^oC$
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity

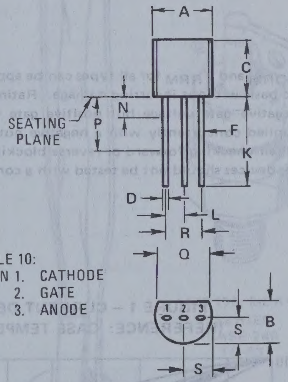
PLASTIC SILICON CONTROLLED RECTIFIERS

0.8 AMPERE RMS
100 and 200 VOLTS



MAXIMUM RATINGS(1)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR115 MCR120	V_{RRM}	 150 200	Volts
Forward Current RMS (See Figures 1 & 2) (All Conduction Angles)	$I_{T(RMS)}$	0.8	Amp
Peak Forward Surge Current, $T_A = 25^oC$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, $T_A = 25^oC$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, $T_A = 25^oC$	P_{GM}	0.1	Watt
Average Gate Power — Forward, $T_A = 25^oC$	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward, $T_A = 25^oC$ (300 µs, 120 PPS)	I_{GFM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GRM}	5.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}	T_J	-65 to +110	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC
Lead Solder Temperature (<1/16″ from case, 10 s max)	—	+230	^oC



STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

(1) Temperature reference point for all case temperatures in center of flat portion of package. ($T_C = +110^oC$ unless otherwise noted.)

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) (T_C = 110°C)	MCR115 MCR120	V_{DRM}	150 200	– –	Volts
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 110°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 110°C)		I_{RRM}	–	100	μA
Forward "On" Voltage (Note 2) (I_{TM} = 1.0 A peak @ T_A = 25°C)		V_{TM}	–	1.7	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	I_{GT}	–	200	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C T_C = -65°C	V_{GT}	– –	0.8 1.2	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms)	T_C = 110°C	V_{GD}	0.1		
Holding Current (Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = 25°C T_C = -65°C	I_H	– –	5.0 10	mA
Thermal Resistance, Junction to Case		θ_{JC}	–	75	°C/W
Thermal Resistance, Junction to Ambient		θ_{JA}	–	200	°C/W

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≤ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

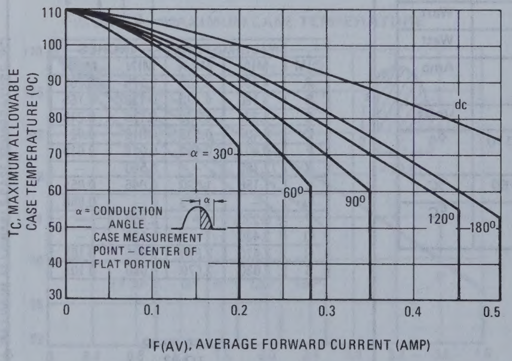
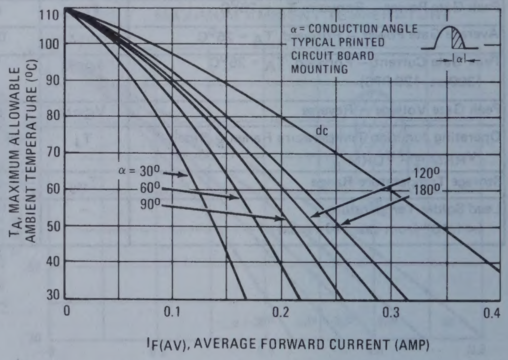


FIGURE 2 – CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)



MCR154, MCR155 (SILICON)
MCR156, MCR157

THYRISTORS

SILICON CONTROLLED RECTIFIERS

. . . designed for high frequency power switching applications such as inverters, choppers, transmitters, induction heaters, cycloconverters and high frequency lighting.

- High Voltage Application Rate — dv/dt = 200 Volts/μs (Min), MCR154, 156
- Fast Turn-Off Time — t_q = 10 μs (Max), MCR154, MCR156

THYRISTORS
PNPN

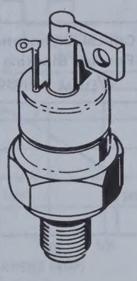
110 AMPERES RMS
100 thru 600 VOLTS

MAXIMUM RATINGS

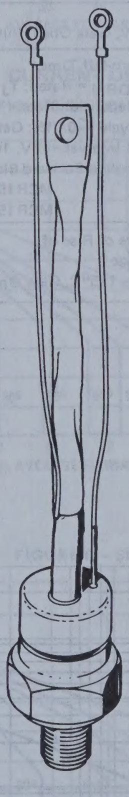
Rating	Symbol	Value	Unit
Repetitive Peak Voltage (T_J = +125°C) MCR154, 155, 156, 157 -10 -20 -30 -40 -50 -60	V_{DRM} (1) and V_{RRM} (1)	 100 200 300 400 500 600	Volts
Non-Repetitive Peak Reverse Blocking Voltage (t ⩽ 5.0 ms) MCR154, 155, 156, 157 -10 -20 -30 -40 -50 -60	V_{RSM}	 200 300 400 500 600 650	Volts
Average On-State Current (T_C = 65°C, 180 Conduction Angle)	$I_{T(AV)}$	70	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = 40 to +125°C)	I_{TSM}	1800	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C) (t = 1.5 ms) (t = 8.3 ms)	I^2t	 9,500 13,000	A^2s
Peak Gate Power	P_{GM}	15	Watts
Average Gate Power	$P_{G(AV)}$	3.0	Watt
Peak Forward Gate Current	I_{GM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (2)	—	150 175	in.lb. Kg — cm

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.3	°C/W



MCR156, MCR157
SERIES
CASE 246
TO-83



MCR154, MCR155
SERIES
CASE 219
TO-94

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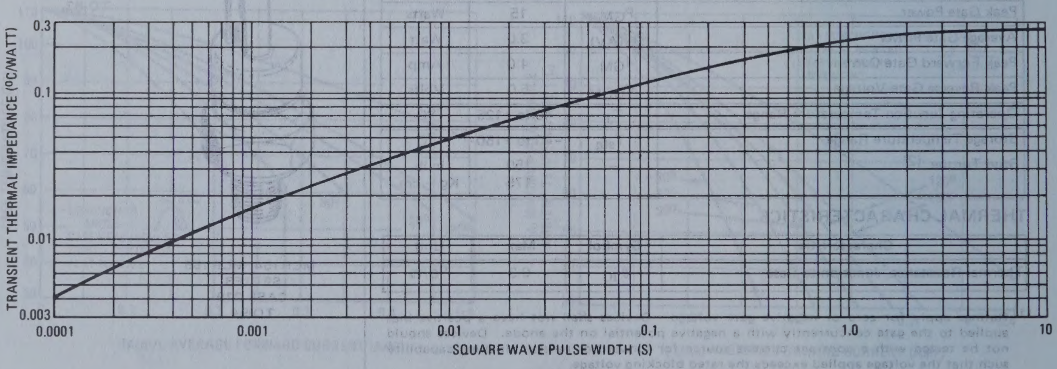
(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or seal broken.

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, $T_J = 125^oC$)	I_{DRM}	–	–	10	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, $T_J = 125^oC$)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 500 A Peak, Duty Cycle = 0.01%)	V_{TM}	–	–	3.0	Volts
Gate Trigger Current (Anode Voltage = 6 V, R_L = 3.0 ohms, $t_p \geqslant 20\ \mu s$) $T_J = 25^oC$ $T_J = -40^oC$ $T_J = +125^oC$	I_{GT}	– – –	50 100 30	150 200 120	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 ohms, $T_J = -40^oC$) (V_{DRM} = Rated, R_L = 1000 ohms, $T_J = +125^oC$)	V_{GT}	– 0.25	– –	3.0 –	Volts
Holding Current (Anode Voltage = 24 V, Gate Open, Initiating Current = 2.0 A)	I_H	–	30	200	mA
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); V_{DRM} = Rated; $T_J = +125^oC$; di_R/dt = 5.0 A/μs; Repetition Rate = 1.0 pps; I_{TM} = 50 A; Duty Cycle $\leqslant$0.01%; Gate Bias during Turn-Off Interval = 0 V, 100 ohms; Rate of Rise of Reapplied Forward Blocking Voltage = 20 V/μs Linear) MCR154, 156 MCR155, 157	t_q	– –	– –	10 20	μs
Critical Exponential Rate of Rise of Forward Blocking Voltage (V_{DRM} = Rated, $T_J = 125^oC$, Gate Open) MCR154, 156 MCR155, 157	dv/dt	200 100	– –	– –	V/μs

FIGURE 1 – THERMAL RESPONSE



FORWARD POWER DISSIPATION

FIGURE 2 – SQUARE WAVE

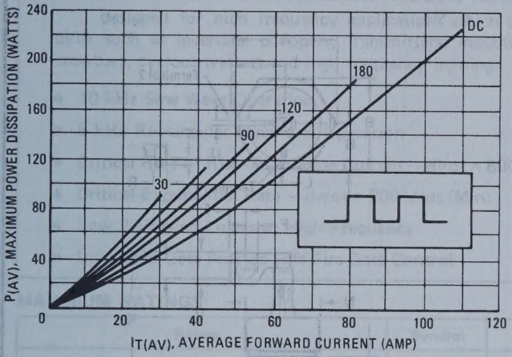


FIGURE 3 – SINE WAVE

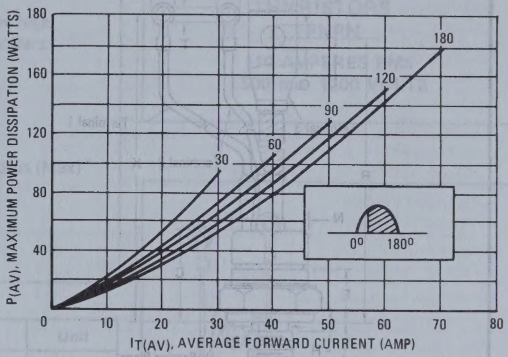
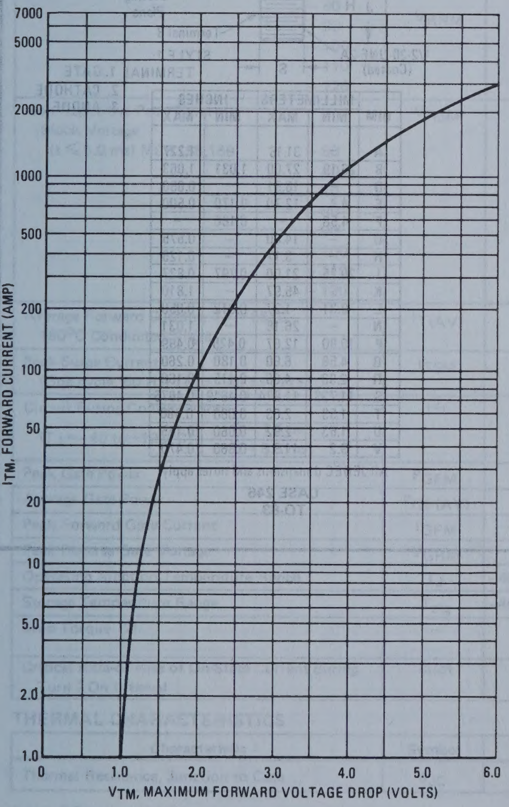


FIGURE 4 – FORWARD CONDUCTION CHARACTERISTICS



CURRENT DERATING

FIGURE 5 – SQUARE WAVE

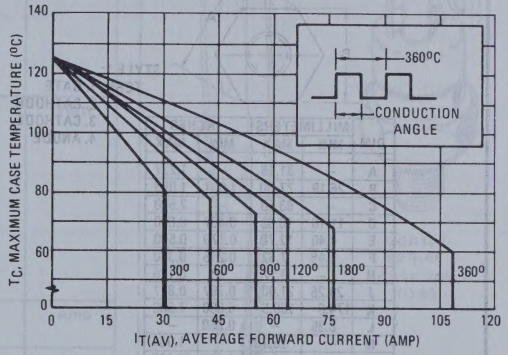
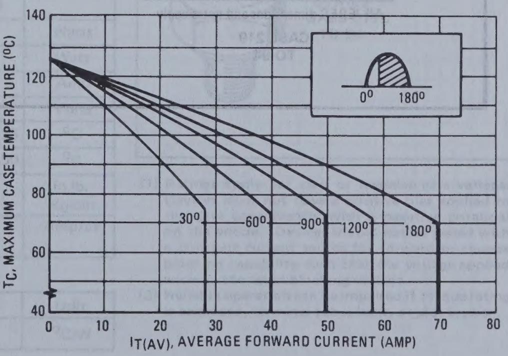
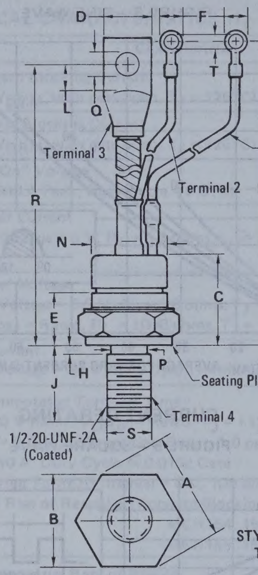


FIGURE 6 – SINE WAVE



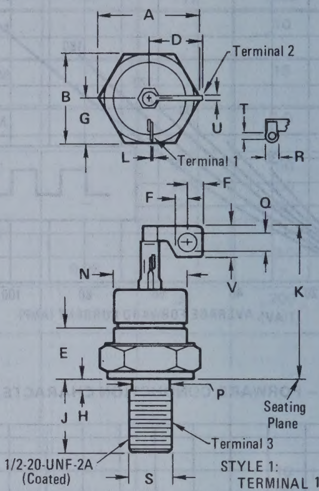

D
F
T
L
Q
Terminal 3
Terminal 1
Terminal 2
K
R
N
C
E
H
P
Seating Plane
J
Terminal 4
1/2-20-UNF-2A
(Coated)
S
A
B

STYLE 1:
TERM. 1. GATE
2. CATHODE
3. CATHODE
4. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	31.16	–	1.227
B	26.19	27.00	1.031	1.063
C	–	63.50	–	2.500
D	11.10	16.50	0.437	0.650
E	4.40	12.70	0.170	0.500
F	5.46	7.62	0.215	0.300
H	–	3.17	–	0.125
J	20.25	21.00	0.797	0.827
K	174.0	190.5	6.850	7.500
L	6.35	–	0.250	–
N	–	26.18	–	1.031
P	10.80	12.67	0.425	0.499
Q	6.61	7.87	0.260	0.310
R	146.7	159.1	5.775	6.265
S	11.733	11.874	0.4619	0.4675
T	3.56	3.81	0.140	0.150

All JEDEC dimensions and notes apply

CASE 219
TO-94


A
D
Terminal 2
B
G
T
U
R
L
Terminal 1
F
F
Q
N
V
K
E
P
Seating Plane
J
H
Terminal 3
1/2-20-UNF-2A
(Coated)
S

STYLE 1:
TERMINAL 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	31.16	–	1.227
B	26.19	27.00	1.031	1.063
D	–	16.51	–	0.650
E	4.4	12.70	0.170	0.500
F	4.58	–	0.180	–
G	–	14.60	–	0.575
H	–	3.17	–	0.125
J	20.25	21.00	0.797	0.827
K	–	45.97	–	1.810
L	0.31	1.27	0.012	0.050
N	–	26.18	–	1.031
P	10.80	12.67	0.425	0.499
Q	4.58	6.60	0.180	0.260
R	2.93	4.06	0.115	0.160
S	11.733	11.874	0.4619	0.4675
T	1.53	2.03	0.060	0.080
U	1.53	2.92	0.060	0.115
V	9.2	11.9	0.360	0.470

All JEDEC dimensions and notes apply

CASE 246
TO-83

MCR158 (SILICON)
MCR159

INTEGRATED GATE THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for high frequency applications which require high di/dt such as inverters, choppers, transmitters, induction heaters, crowbars, cycloconverters and high frequency lighting.

- 10 kHz Sine Wave Operation
- 5 kHz Rectangular Waveform Operation
- Critical Rate-of-Rise of On-State Current — di/dt = 800 Amp/µs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/µs (Min)
- Low Switching Losses at High Frequency
- Integrated Gate Permits Soft-Fire Gate Control

INTEGRATED GATE
THYRISTORS
PNPN

110 AMPERES RMS
500 thru 1200 VOLTS

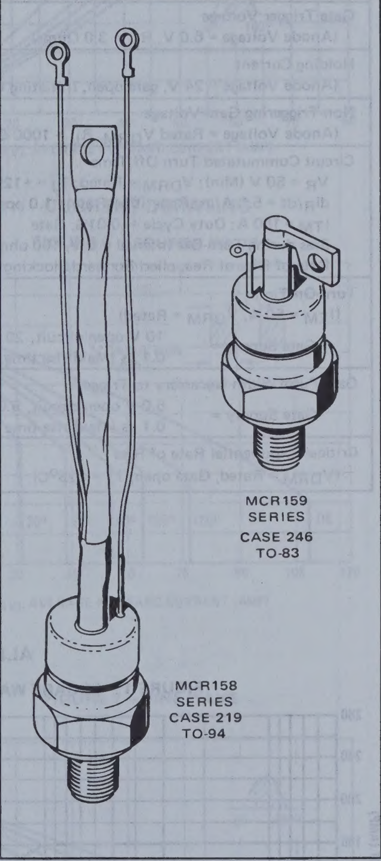
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak off-State Voltage (T_J = +125°C) MCR158,159	– 50	$V_{DRM(1)}$ V_{RRM}	500	Volts
	– 60		600	
	– 70		700	
	– 80		800	
	– 90		900	
	– 100		1000	
	– 110		1100	
	– 120		1200	
Non-Repetitive Peak Reverse Block Voltage (t ⩽ 5.0 ms) MCR158,159	– 50	V_{RSM}	600	Volts
	– 60		720	
	– 70		840	
	– 80		960	
	– 90		1080	
	– 100		1200	
	– 110		1300	
	– 120		1400	
Average Forward Current, T_C = 65°C 180°C Conducted Angle		$I_{T(AV)}$	70	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = –40 to +125°C)		I_{TSM}	1600	Amp
Circuit Fusing Considerations (T_J = –40 to +125°C)	(t = 1.5 ms)	I^2t	5200	A^2s
	(t = 8.3 ms)		10,500	
Peak Gate Power		P_{GFM}	15	Watts
Average Gate Power		$P_{GF(AV)}$	3.0	Watt
Peak Forward Gate Current		I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	–40 to +125	°C
Storage Temperature Range		T_{stg}	–40 to +150	°C
Stud Torque (2)		—	150 175	in.lb. Kg-cm
Critical Rate-of-Rise of On-State Current during Turn – On Interval		di/dt	800	Amp/µs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.3	°C/W

*With 0.05 µF and 20 ohm snubber circuit.



(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or seal broken.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	10	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 500 A Peak, Duty Cycle ⩽ 0.01%)	V_{TM}	–	–	3.0	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	–	–	Volts
Circuit Commutated Turn-Off Time V_R = 50 V (Min); V_{DRM} = Rated; T_J = +125°C; di_R/dt = 5.0 A/μs; Repetition Rate = 1.0 pps; I_{TM} = 150 A; Duty Cycle ⩽ 0.01%; Gate Bias during Turn-Off Interval = 0 V, 100 ohms; Rate of Rise of Reapplied Forward Blocking Voltage = 20 V/μs Linear	t_q	–	–	30	μs
Turn-On Time (I_{TM} = 50 A, V_{DRM} = Rated) Gate Supply = 10 V open circuit, 20 Ohm 0.1 μs (Max) rise time	t_{on}	–	2.0	–	μs
Gate Pulse Width Necessary to Trigger Gate Supply = 5.0 V open circuit, 5.0 Ohm 0.1 μs (Max) rise time		–	–	10	μs
Critical Exponential Rate of Rise (V_{DRM} = Rated, Gate open, T_J = 125°C)	dv/dt	200	–	–	V/μs

ALLOWABLE PEAK ON-STATE CURRENT

FIGURE 1 – SQUARE WAVE

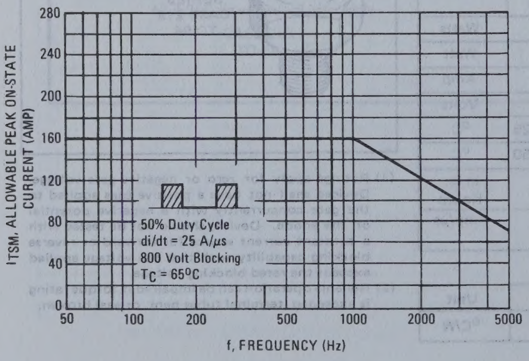
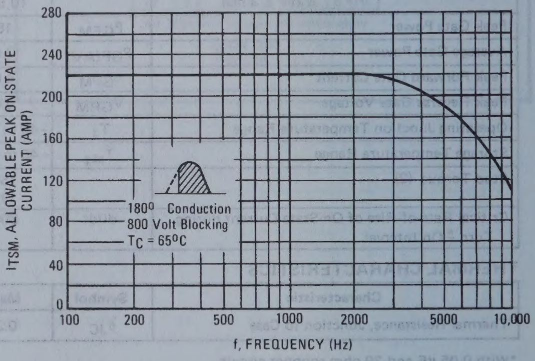


FIGURE 2 – SINE WAVE



FORWARD POWER DISSIPATION

FIGURE 3 – SQUARE WAVE

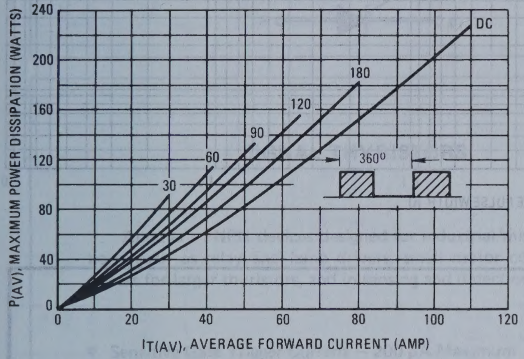


FIGURE 4 – SINE WAVE

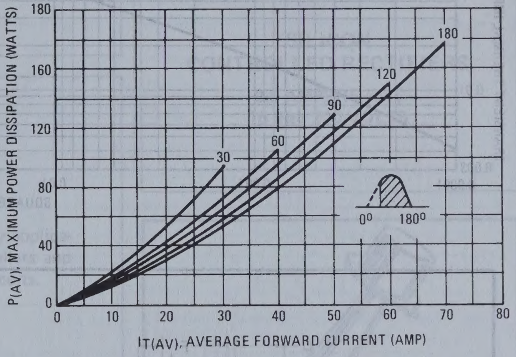
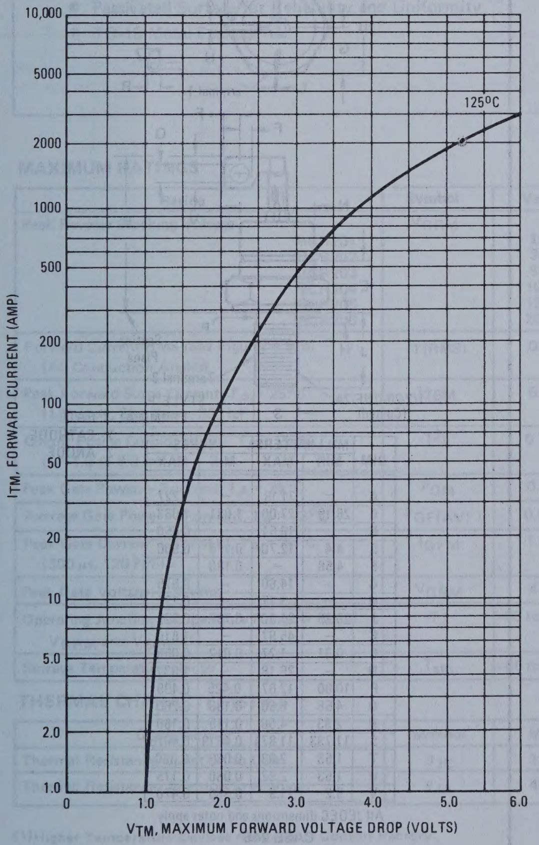


FIGURE 5 – FORWARD CONDUCTION CHARACTERISTICS



CURRENT DERATING

FIGURE 6 – SQUARE WAVE

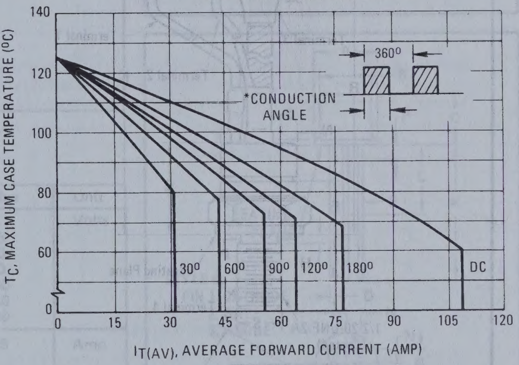


FIGURE 7 – SINE WAVE

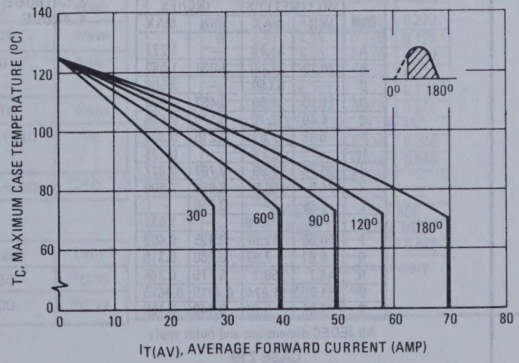
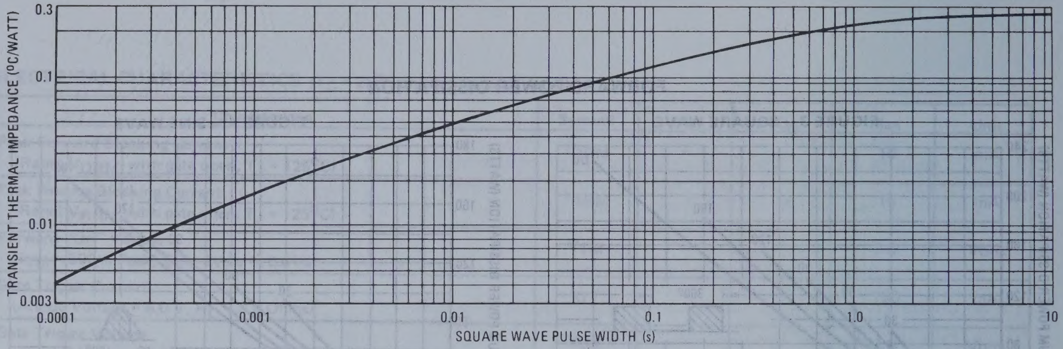
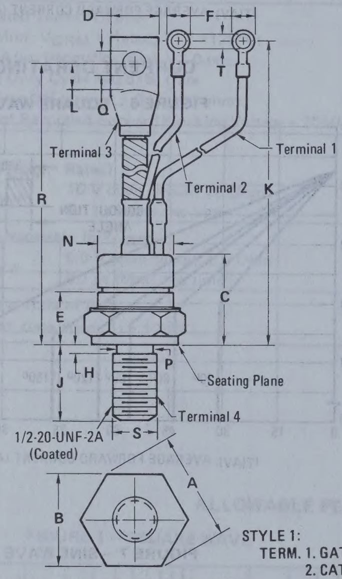


FIGURE 8 – THERMAL RESPONSE



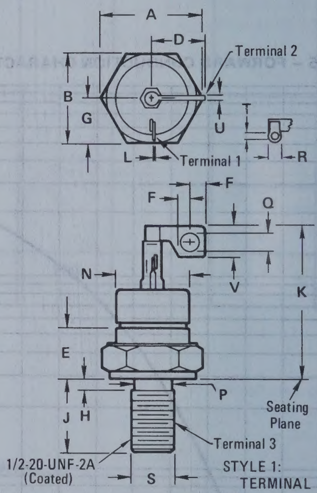

D
F
T
L
Q
Terminal 3
Terminal 1
Terminal 2
K
R
N
C
E
H
P
J
Seating Plane
Terminal 4
1/2-20-UNF-2A
(Coated)
S
A
B

STYLE 1:
TERM. 1. GATE
2. CATHODE
3. CATHODE
4. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	31.16	–	1.227
B	26.19	27.00	1.031	1.063
C	–	63.50	–	2.500
D	11.10	16.50	0.437	0.650
E	4.40	12.70	0.170	0.500
F	5.46	7.62	0.215	0.300
H	–	3.17	–	0.125
J	20.25	21.00	0.797	0.827
K	174.0	190.5	6.850	7.500
L	6.35	–	0.250	–
N	–	26.18	–	1.031
P	10.80	12.67	0.425	0.499
Q	6.61	7.87	0.260	0.310
R	146.7	159.1	5.775	6.265
S	11.733	11.874	0.4619	0.4675
T	3.56	3.81	0.140	0.150

All JEDEC dimensions and notes apply

CASE 219
TO-94


A
D
Terminal 2
B
G
T
U
L
Terminal 1
R
F
F
Q
N
V
K
E
P
J
H
Seating Plane
Terminal 3
1/2-20-UNF-2A
(Coated)
S

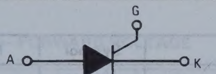
STYLE 1:
TERMINAL 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	31.16	–	1.227
B	26.19	27.00	1.031	1.063
D	–	16.51	–	0.650
E	4.4	12.70	0.170	0.500
F	4.58	–	0.180	–
G	–	14.60	–	0.575
H	–	3.17	–	0.125
J	20.25	21.00	0.797	0.827
K	–	45.97	–	1.810
L	0.31	1.27	0.012	0.050
N	–	26.18	–	1.031
P	10.80	12.67	0.425	0.499
Q	4.58	6.60	0.180	0.260
R	2.93	4.06	0.115	0.160
S	11.733	11.874	0.4619	0.4675
T	1.53	2.03	0.060	0.080
U	1.53	2.92	0.060	0.115
V	9.2	11.9	0.360	0.470

All JEDEC dimensions and notes apply

CASE 246
TO-83

MCR201 (SILICON)
thru
MCR206



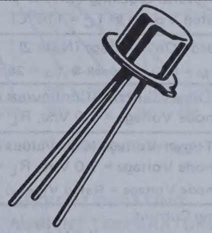
SILICON CONTROLLED RECTIFIERS

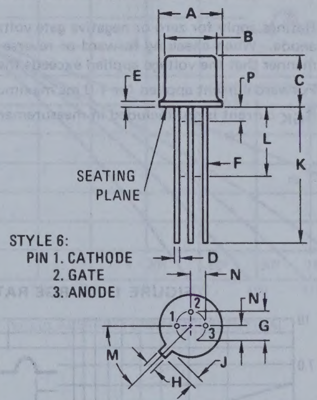
0.5 AMPERE RMS
15 thru 200 VOLTS

SIGNAL THYRISTORS

. . . Annular PNPN devices designed for industrial/military applications such as relay and lamp drivers, small motor controllers and drivers for larger thyristors, and in sensing and detection circuits.

- Sensitive Gate Trigger Current — 200 μA Maximum
- Low Reverse and Forward Blocking Current — 100 μA Maximum, $T_C = 125^\circ C$
- Low Holding Current — 5.0 mA Maximum
- Passivated Surface for Reliability and Uniformity
- TO-18 Metal Package





STYLE 6:
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage	V_{RRM}		Volts
MCR201		15	
MCR202		30	
MCR203		60	
MCR204		100	
MCR205		150	
MCR206		200	
Forward Current RMS (See Figures 4 & 5) (All Conduction Angles)	$I_{T(RMS)}$	0.5	Amp
Peak Forward Surge Current, $T_A = 25^\circ C$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	6.0	Amp
Circuit Fusing Considerations, $T_A = 25^\circ C$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Peak Gate Power — Forward, $T_A = 25^\circ C$	P_{GM}	0.1	Watt
Average Gate Power — Forward, $T_A = 25^\circ C$	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward, $T_A = 25^\circ C$ (300 μs, 120 PPS)	I_{GFM}	1.0	Amp
Peak Gate Voltage — Reverse	V_{GRM}	4.0	Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}(1)	T_J	-65 to +110	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	150	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	400	°C/W

(1) Higher Temperature Devices Available — Consult Factory.

ELECTRICAL CHARACTERISTICS (R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)		V_{DRM}			Volts
	MCR201		15	–	
	MCR202		30	–	
	MCR203		60	–	
	MCR204		100	–	
	MCR205		150	–	
	MCR206		200	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 110°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 110°C)		I_{RRM}	–	1.5	μA
Forward "On" Voltage (Note 2) (I_{TM} = 500 mA peak @ T_A = 25°C)		V_{TM}	–	1.7	Volts
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	I_{GT}	–	200	μA
	T_C = -65°C		–	350	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	V_{GT}	–	0.8	Volts
	T_C = -65°C		–	1.2	
(Anode Voltage = Rated V_{DRM})	T_C = 110°C	V_{GD}	0.1	–	
Holding Current (Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = 25°C	I_H	–	5.0	mA
	T_C = -65°C		–	10	

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ≦ 1.0%.
3. R_{GK} current is not included in measurement.

FIGURE 1 – SURGE RATINGS

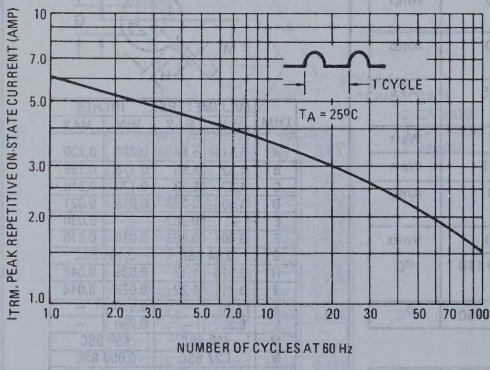


FIGURE 2 – POWER DISSIPATION

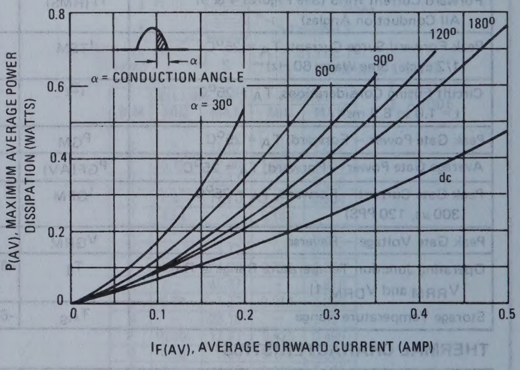


FIGURE 3 – FORWARD VOLTAGE

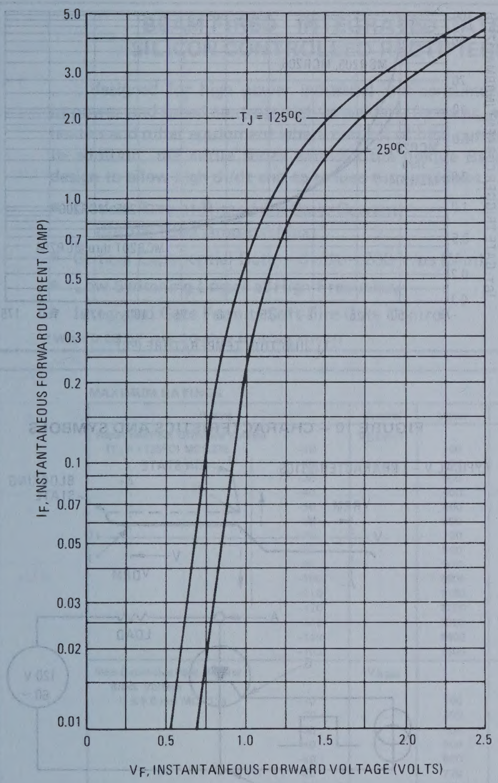


FIGURE 4 – CURRENT DERATING
(REFERENCE: CASE TEMPERATURE)

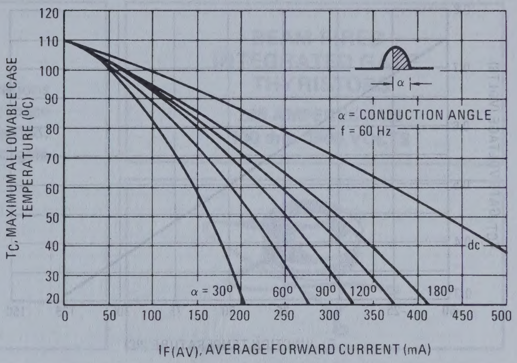


FIGURE 5 – CURRENT DERATING
(REFERENCE: AMBIENT TEMPERATURE)

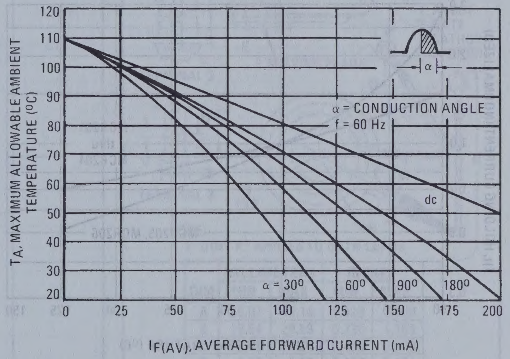
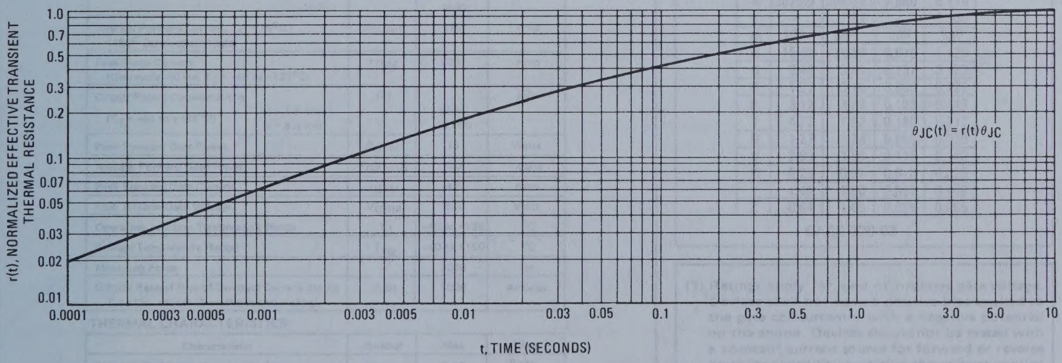


FIGURE 6 – THERMAL RESPONSE



TYPICAL CHARACTERISTICS

FIGURE 7 – GATE TRIGGER VOLTAGE

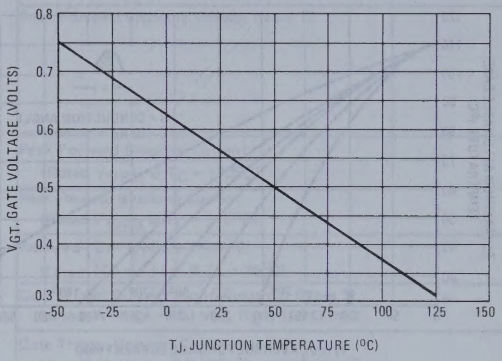


FIGURE 8 – GATE TRIGGER CURRENT

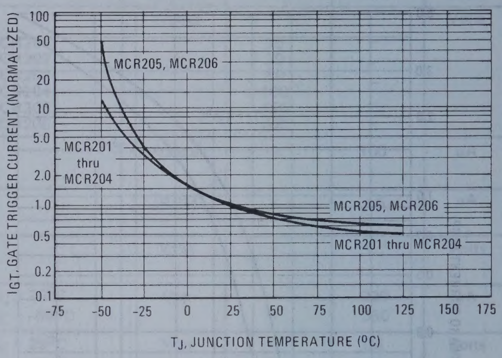


FIGURE 9 – HOLDING CURRENT

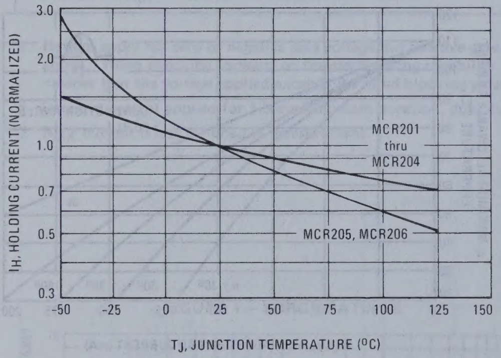
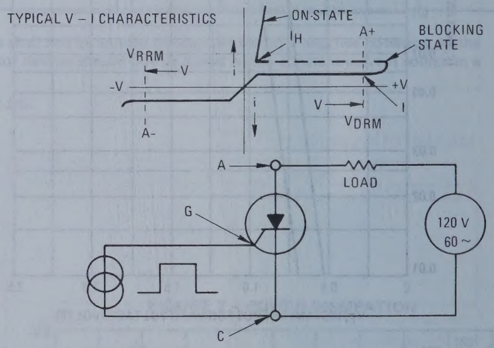


FIGURE 10 – CHARACTERISTICS AND SYMBOLS


TYPICAL V – I CHARACTERISTICS
ON-STATE
I_H
A+
BLOCKING STATE
V_{RRM}
-V
V
+V
I
V
V_{DRM}
i
A-
A
LOAD
G
120 V 60 ~
C

MCR235 SERIES (SILICON)

BEAM-FIRED INTEGRATED GATE SILICON CONTROLLED RECTIFIERS

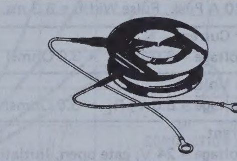
. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed. In addition, the entire series employs the unique Beam-Fired gate design to allow high di/dt and to reduce turn-on losses.

- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/µs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/µs (Min)
- Low Switching Losses at High Frequency
- Integrated Gate Permits Soft-Fire Gate Control

*With 0.05 µF and 20-ohm snubber circuit

BEAM-FIRED INTEGRATED GATE THYRISTORS

235 AMPERES RMS
100 thru 1500 VOLTS

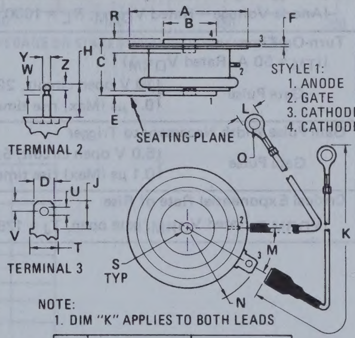


MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = +125°C) MCR235	-10	V_{DRM}(1) V_{RRM}	100	Volts
	-20		200	
	-30		300	
	-40		400	
	-50		500	
	-60		600	
	-70		700	
	-80		800	
	-90		900	
	-100		1000	
	-110		1100	
	-120		1200	
	-130		1300	
	-140		1400	
	-150		1500	
Non-Repetitive Peak Reverse Block Voltage (t ≤ 5.0 ms) MCR235	-10	V_{RSM}	200	Volts
	-20		300	
	-30		400	
	-40		500	
	-50		600	
	-60		720	
	-70		840	
	-80		960	
	-90		1080	
	-100		1200	
	-110		1300	
	-120		1450	
	-130		1550	
	-140		1650	
	-150		1800	
Average Forward Current, T_C = 75°C (180° Conduction Angle)		$I_{T(AV)}$	150	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)		I_{TSM}	1800	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C)	(t = 1.5 ms) (t = 8.3 ms)	I^2t	9500 13,000	A^2s
Peak Forward Gate Power		P_{GFM}	15	Watts
Average Forward Gate Power		$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current		I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Mounting Force		–	1000	lbs
Critical Rate-of-Rise of On-State Current during Turn-On Interval (Non-Repetitive Rating)		di/dt	1000	Amp/µs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.13	°C/W



STYLE 1:
1. ANODE
2. GATE
3. CATHODE
4. CATHODE

NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
H	2.54	–	0.100	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.065

CASE 220-03

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 220 A Peak, Pulse Width = 8.3 ms, Duty Cycle ≤ 1.0%)	V_{TM}	–	–	1.6	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	–	–	Volts
Turn-On Time (I_{TM} = 50 A, Rated V_{DRM}) Gate Pulse {10 V open circuit, 20 Ohm Source 0.1 μs (Max) rise time	t_{on}	–	2.0	–	μs
Gate Pulse Width Necessary to Trigger Gate Pulse {5.0 V open circuit, 5.0 Ohm Source 0.1 μs (Max) rise time		–	–	10	μs
Critical Exponential Rate of Rise (V_{DRM} = Rated V_{DRM}, gate open, T_J = 125°C)	dv/dt	200	–	–	V/μs

CURRENT DERATING

(f = 50 to 400 Hz)

FIGURE 1 – SQUARE WAVE

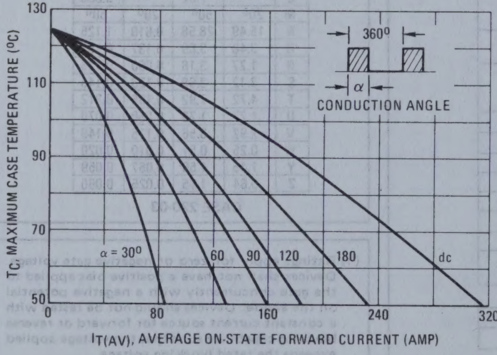
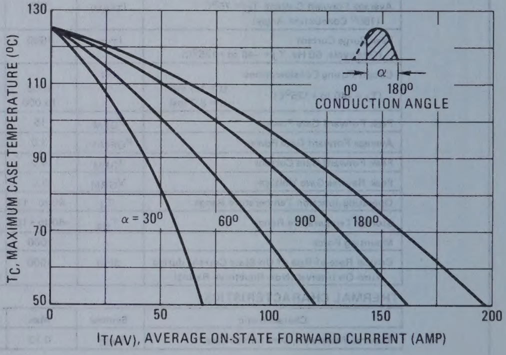


FIGURE 2 – SINE WAVE



FORWARD POWER DISSIPATION

(f = 50 to 400 Hz)

FIGURE 3 – SQUARE WAVE

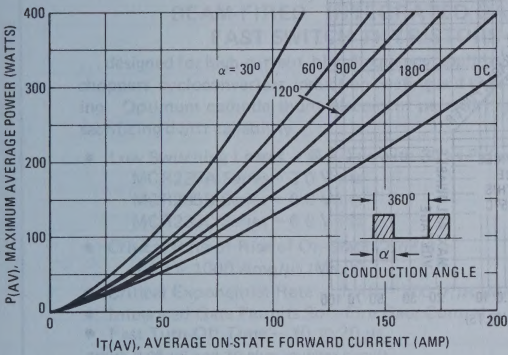


FIGURE 4 – SINE WAVE

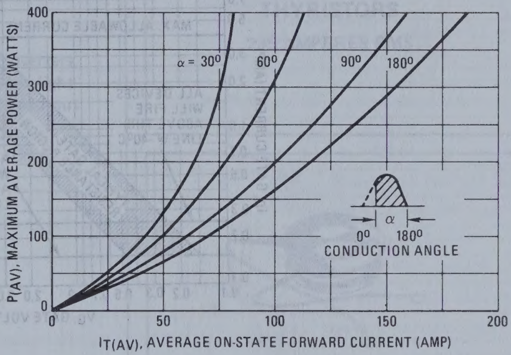


FIGURE 5 – MAXIMUM ON-STATE CHARACTERISTICS

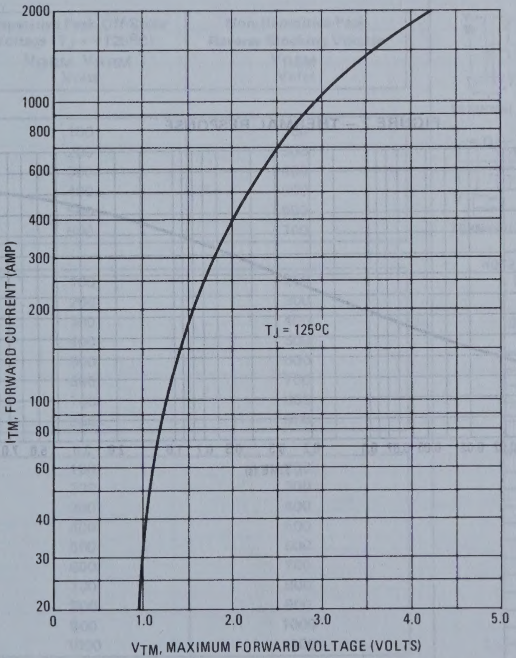


FIGURE 6 – TRIGGERING CHARACTERISTICS

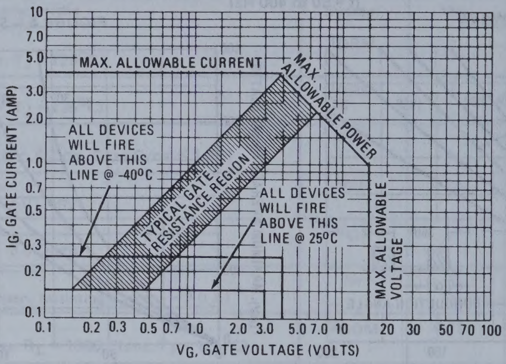
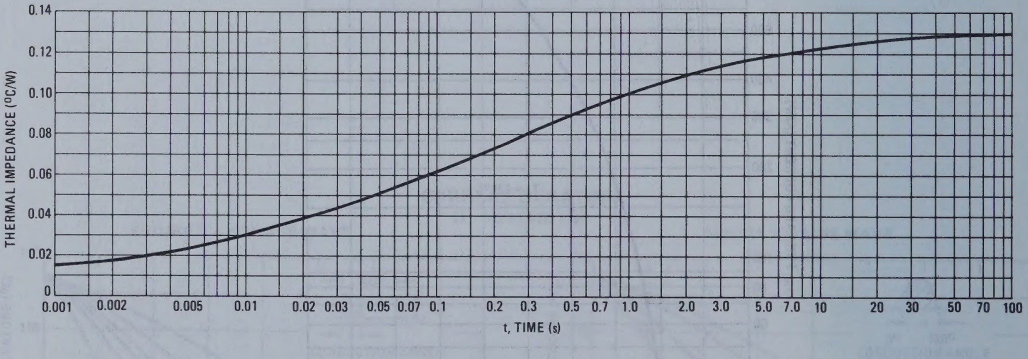


FIGURE 7 – THERMAL RESPONSE



MCR235A SERIES (SILICON)
MCR235B SERIES
MCR235C SERIES

Advance Information

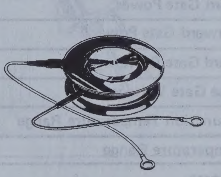
BEAM-FIRED INTEGRATED GATE FAST SWITCH THYRISTORS

. . . designed for high-current, high-frequency applications in inverters, choppers, cycloconverters, induction heating and high-frequency lighting. Optimum cathode shunt placement permits high di/dt without sacrificing dv/dt capability.

- Low Switching Losses — @ 3.0 μs with 30 μs Pulse, I_P = 100 A
  MCR235A Series = 3.0 Volts
  MCR235B Series = 6.0 Volts
  MCR235C Series = 6.0 Volts
- Critical Rate-of-Rise of On-State Current —
  di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/μs (Min)
- Integrated Gate Permits Soft-Fire Gate Control
- Fast Turn-Off Time — 10 to 20 μs

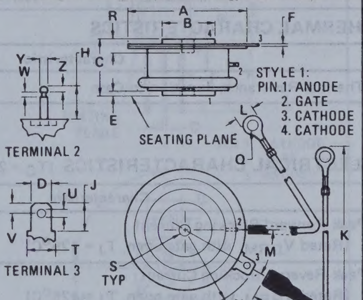
*With 0.05 μF and 20 ohm snubber circuit.

BEAM-FIRED
INTEGRATED GATE
THYRISTORS
235 AMPERES RMS



MAXIMUM RATINGS

Device Type	Repetitive Peak Off-State Voltage (T_J = +125°C) V_{DRM}, V_{RRM} Volts	Non-Repetitive Peak Reverse Blocking Voltage V_{RSM} Volts
Turn-Off Time = 10 μs Max		
MCR235A -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
Turn-Off Time = 15 μs Max		
MCR235B -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
-70	700	800
-80	800	900
Turn-Off Time = 20 μs Max		
MCR235C -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
-70	700	800
-80	800	900
-90	900	1000
-100	1000	1100



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
H	2.54	–	0.100	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.065

CASE 220-03

This is advance information on a new introduction and specifications are subject to change without notice.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Average Forward Current, $T_C = 60^oC$ (180° Conduction Angle)	$I_{T(AV)}$	150	Amp
Peak Surge Current (One Cycle, 60 Hz, T_J = -40 to +125°C)	I_{TSM}	1600	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.5 – 8.3 ms)	I^2t	10,500	A^2s
Peak Forward Gate Power	P_{GFM}	15	Watts
Average Forward Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Force	–	1000 ± 200	lbs
Critical Rate-of-Rise of On-State Current — Repetitive Non-Repetitive	di/dt	200 1000	Amp/μs

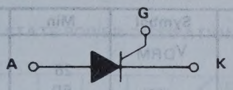
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.13	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, $T_J = 125^oC$)	I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, $T_J = 125^oC$)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 220 A Peak, Pulse Width = 8.3 ms, Duty Cycle = ≤1.0%, $T_J = 25^oC$)	V_{TM}	–	–	1.85	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	50	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, $T_J = 125^oC$)	V_{GDM}	0.15	–	–	Volts
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); Rated V_{DRM}, $T_J = +125^oC$, MCR235A di_R/dt = 20 A/μs; Repetition Rate = 1.0 pps; MCR235B I_{TM} = 150 A dv/dt = 20 V/μs) MCR235C	t_q	– – –	– – –	10 15 20	μs
Transient Turn-On Voltage MCR235A (V_{DRM} = 100 V, I_{TM} = 200 A, PW = 8.0 μs, MCR235B Gate Drive = 600 mA, rise = 0.1 μs, test point = 4.0 μs) MCR235C	V_{TO}	– – –	– – –	5.0 8.0 8.0	Volts
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, $T_J = 125^oC$)	dv/dt	200	–	–	V/μs

MCR320 SERIES (SILICON)



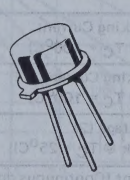
SILICON CONTROLLED RECTIFIERS

. . . designed primarily for industrial applications. Ideally suited for capacitor-discharge ignition, systems, power switching and power control.

- Glass Passivated for High Reliability
- Low Profile Hermetic Package for Tight Printed Circuit Board Applications
- High di/dt Capability

THYRISTORS

7 AMPERES RMS
50-600 VOLTS

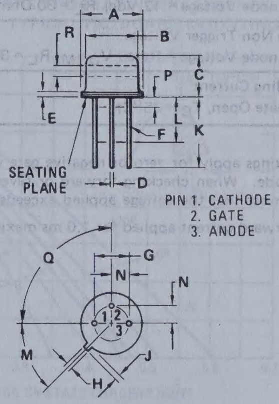


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage	V_{RRM}		Volts
MCR320 –1		25	
–2		50	
–3		100	
–4		200	
–5		300	
–6		400	
–7		500	
–8		600	
Forward Current RMS (See Figures 4 & 5) (All Conduction Angles)	$I_{T(RMS)}$	7.0	Amps
Peak Forward Surge Current, $T_A = 25^oC$ (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	80	Amps
Circuit Fusing Considerations, $T_A = 25^oC$ (t = 1.0 to 8.3 ms)	I^2t	0.15	A^2s
Forward Peak Gate Power, $T_A = 25^oC$	P_{GM}	10	Watts
Forward Average Gate Power, $T_A = 25^oC$	$P_{G(AV)}$	0.5	Watt
Forward Peak Gate Current, $T_A = 25^oC$ (300 μs, 120 PPS)	I_{GM}	10	Amps
Reverse Peak Gate Voltage	V_{GM}	4.0	Volts
Operating Junction Temperature Range	T_J	-40 to +100	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	150	$^oC/W$



PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (1)		V_{DRM}			Volts
	MCR320–1		25	–	
	MCR320–2		50	–	
	MCR320–3		100	–	
	MCR320–4		200	–	
	MCR320–5		300	–	
	MCR320–6		400	–	
	MCR320–7		500	–	
	MCR320–8		600	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 100°C)		I_{DRM}	–	1.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 100°C)		I_{RRM}	–	1.0	mA
Forward "On" Voltage (2) (I_{TM} = 30 A peak @ T_C = 25°C)		V_{TM}	–	2.6	Volts
Gate Trigger Current (Continuous dc) (3) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)		I_{GT}	–	20	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 12 Vdc, R_L = 30 Ohms, T_C = 25°C)		V_{GT}	–	1.5	Volts
Gate Non-Trigger Voltage (Anode Voltage = Rated V_{DRM}, R_L = 30 Ohms, T_C = 100°C)		V_{GD}	0.1	–	Volts
Holding Current (Gate Open, T_C = 25°C)		I_H	–	20	mA

(1) Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.

(2) Forward current applied for 1.0 ms maximum duration, duty cycle ≤1.0%.

FIGURE 1 – TYPICAL PULSE TRIGGER CURRENT

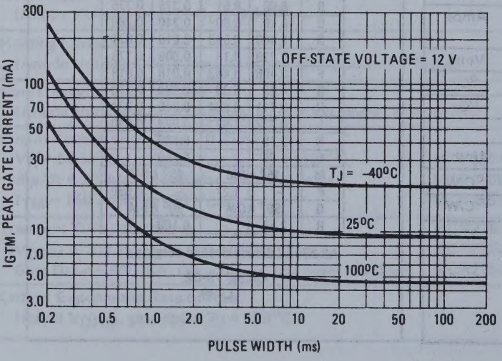


FIGURE 2 – TYPICAL GATE TRIGGER CURRENT

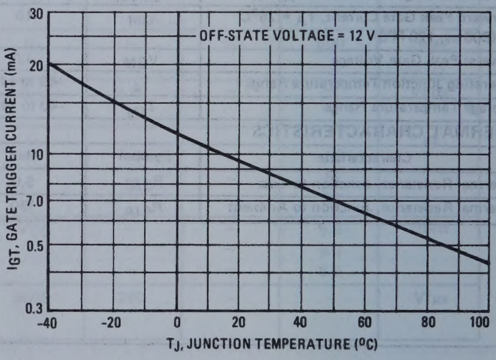


FIGURE 3 – MAXIMUM ON-STATE POWER DISSIPATION

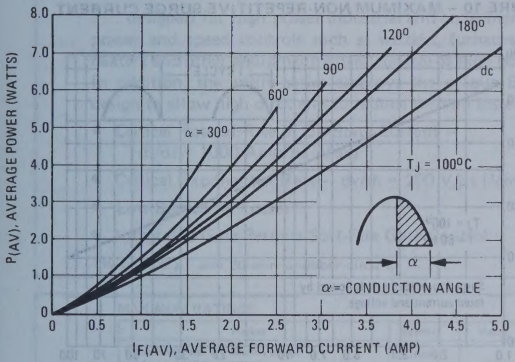


FIGURE 4 – AVERAGE CURRENT DERATING (REFERENCE. CASE TEMPERATURE)

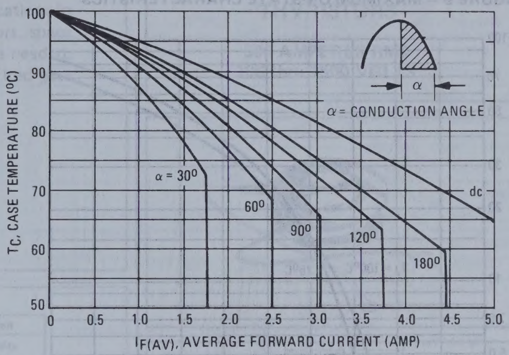


FIGURE 5 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE 4 in. sq. P.C. BOARD)

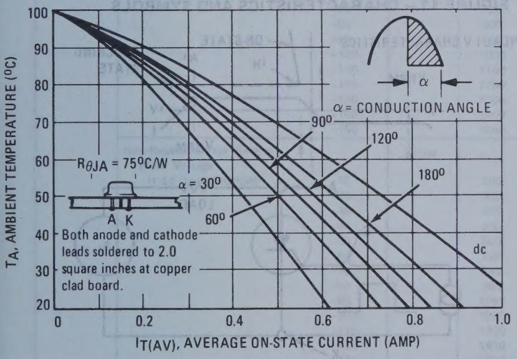


FIGURE 6 – AVERAGE CURRENT DERATING (REFERENCE: AMBIENT TEMPERATURE, TYPICAL P.C. BOARD MOUNTING)

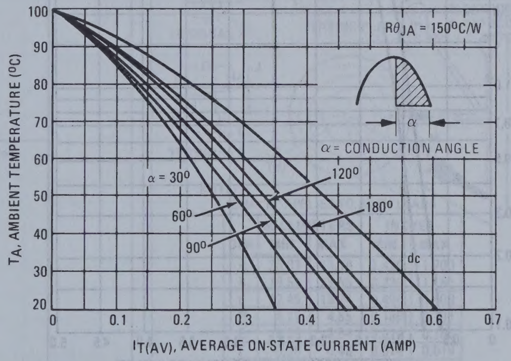


FIGURE 7 – TYPICAL GATE TRIGGER VOLTAGE

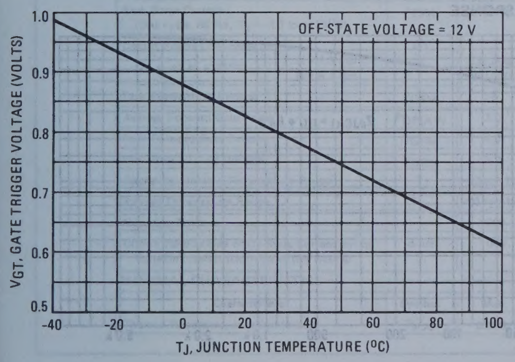


FIGURE 8 – TYPICAL HOLDING CURRENT

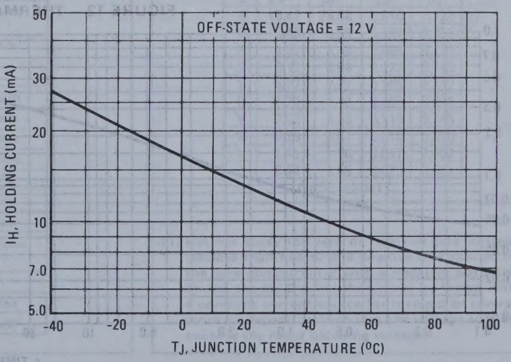


FIGURE 9 – MAXIMUM ON-STATE CHARACTERISTICS

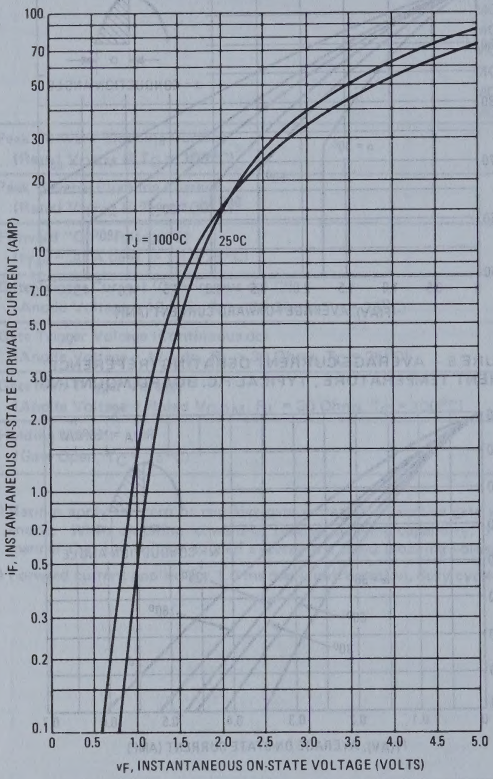


FIGURE 10 – MAXIMUM NON-REPETITIVE SURGE CURRENT

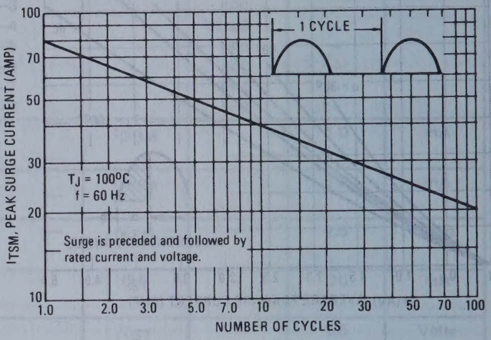


FIGURE 11 – CHARACTERISTICS AND SYMBOLS

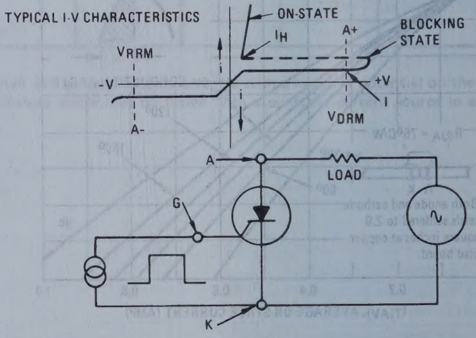
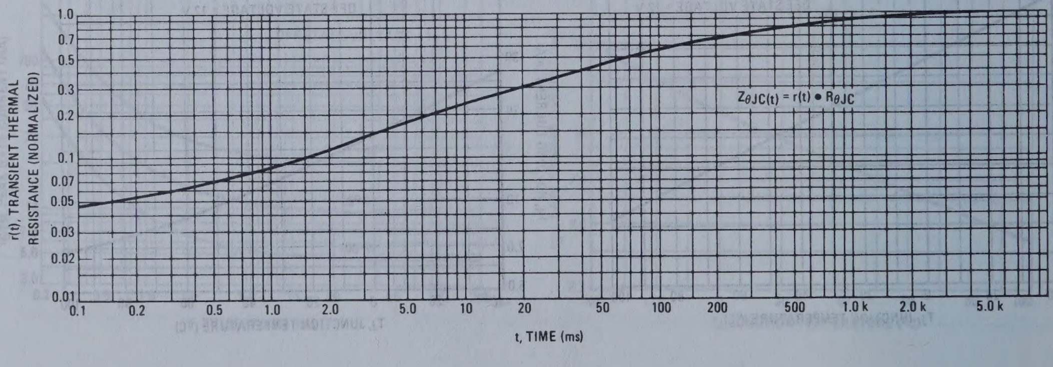

TYPICAL I-V CHARACTERISTICS
ON-STATE
I_H
A+
BLOCKING STATE
V_{RRM}
-V
+V
I
V_{DRM}
A-
A
LOAD
G
K

FIGURE 12 – THERMAL RESPONSE



BEAM-FIRED INTEGRATED GATE SILICON CONTROLLED RECTIFIERS

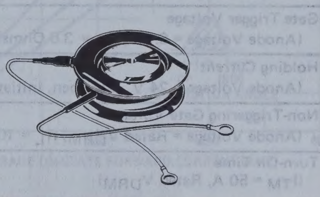
. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed. In addition, the entire series employs the unique Beam-Fired gate design to allow high di/dt and to reduce turn-on losses.

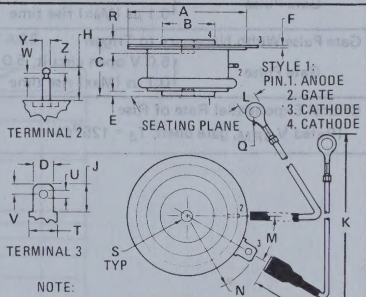
- Critical Rate-of-Rise of On-State Current – di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate – dv/dt = 200 V/μs (Min)
- Low Switching Losses
- Integrated Gate Permits Soft-Fire Gate Control

*With 0.05 μF and 20-ohm snubber circuit.

BEAM-FIRED INTEGRATED GATE THYRISTORS

380 AMPERES RMS
100 thru 1500 VOLTS





NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
H	2.54	–	0.100	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.065

CASE 220-03

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = +125°C) MCR380	-10	$V_{DRM(1)}$	100	Volts
	-20	V_{RRM}	200	
	-30		300	
	-40		400	
	-50		500	
	-60		600	
	-70		700	
	-80		800	
	-90		900	
	-100		1000	
	-110		1100	
	-120		1200	
	-130		1300	
	-140		1400	
	-150		1500	
Non-Repetitive Peak Reverse Block Voltage (t ≤ 5.0 ms) MCR380	-10	V_{RSM}	200	Volts
	-20		300	
	-30		400	
	-40		500	
	-50		600	
	-60		720	
	-70		840	
	-80		960	
	-90		1080	
	-100		1200	
	-110		1300	
	-120		1450	
	-130		1550	
	-140		1650	
	-150		1800	
Average Forward Current (T_C = 72°C) (180° Conduction Angle)		$I_{T(AV)}$	250	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)		I_{TSM}	3500	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C)	(t = 1.5 ms)	I^2t	32,000	A^2s
	(t = 8.3 ms)		50,000	
Peak Forward Gate Power		P_{GFM}	15	Watts
Average Forward Gate Power		$P_{GF(AV)}$	3.0	Watt
Peak Forward Gate Current		I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Mounting Force		–	1000	lbs
Critical Rate-of-Rise of On-State Current during Turn-On Interval (Non-Repetitive Rating)		di/dt	1000	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.095	°C/W

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	—	—	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	—	—	20	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Pulse Width = 8.3 ms, Duty Cycle ≤ 1.0%)	V_{TM}	—	—	2.4	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	—	—	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	—	—	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	—	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	—	—	Volts
Turn-On Time (I_{TM} = 50 A, Rated V_{DRM}) Gate Pulse {10 V open circuit, 20 Ohm Source; 0.1 μs (Max) rise time}	t_{on}	—	2.0	—	μs
Gate Pulse Width Necessary to Trigger Gate Pulse {5.0 V open circuit, 5.0 Ohm Source; 0.1 μs (Max) rise time}		—	—	10	μs
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, T_J = 125°C)	dv/dt	200	—	—	V/μs

CURRENT DERATING

(f = 50 to 400 Hz)

FIGURE 1 – SQUARE WAVE

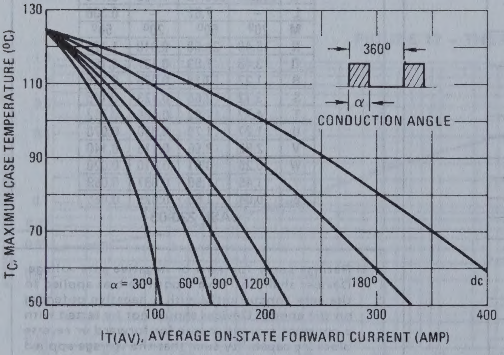
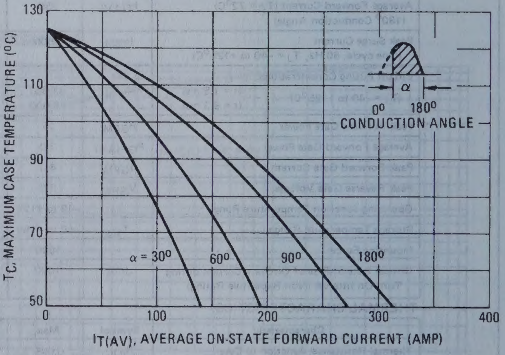


FIGURE 2 – SINE WAVE



FORWARD POWER DISSIPATION

(f = 50 to 400 Hz)

FIGURE 3 – SQUARE WAVE

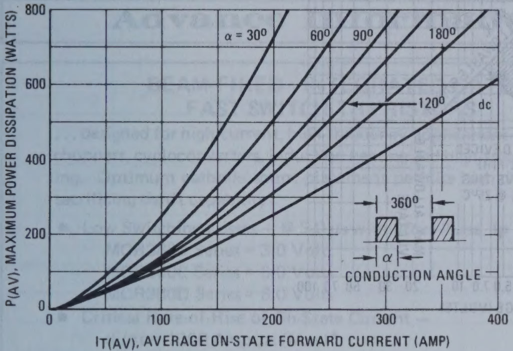


FIGURE 4 – SINE WAVE

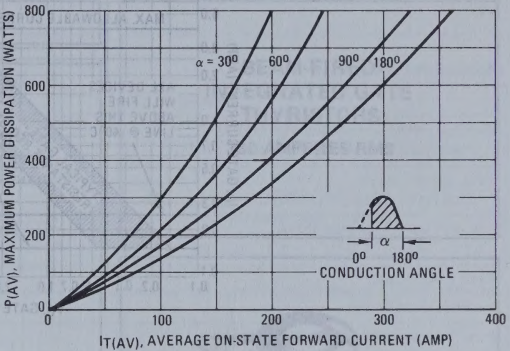


FIGURE 5 – MAXIMUM ON-STATE VOLTAGE

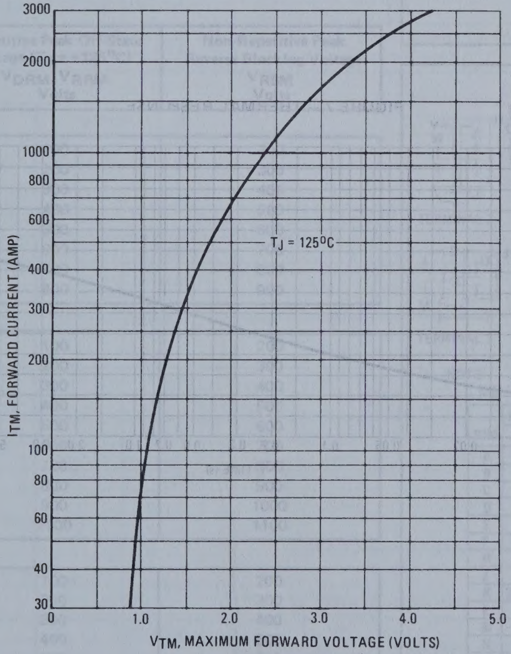


FIGURE 6 – TRIGGERING CHARACTERISTICS

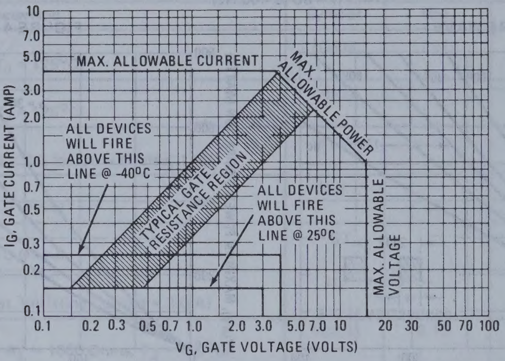
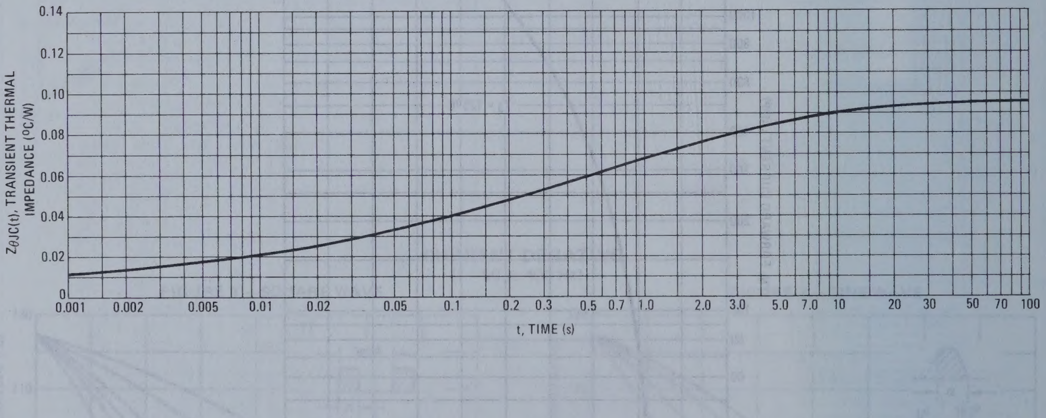


FIGURE 7 – THERMAL RESPONSE



MCR380B SERIES (SILICON)
MCR380C SERIES
MCR380D SERIES

Advance Information

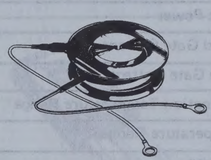
BEAM-FIRED INTEGRATED GATE FAST SWITCH THYRISTORS

. . . designed for high-current, high-frequency applications in inverters, choppers, cycloconverters, induction heating and high-frequency lighting. Optimum cathode shunt placement permits high di/dt without sacrificing dv/dt capability.

- Low Switching Losses — @ 3.0 μs with 30 μs Pulse, Ip = 150 A
  MCR380B Series = 3.0 Volts
  MCR380C Series = 6.0 Volts
  MCR380D Series = 6.0 Volts
- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/μs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/μs (Min)
- Integrated Gate Permits Soft-Fire Gate Control
- Fast Turn-Off Time — 15 to 30 μs

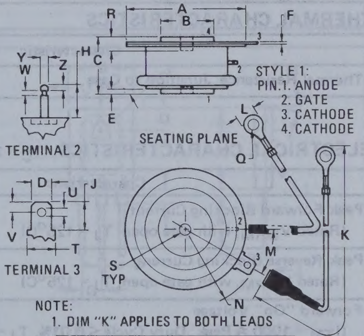
*With 0.05 μF and 20 ohm snubber circuit.

BEAM-FIRED
INTEGRATED GATE
THYRISTORS
380 AMPERES RMS



MAXIMUM RATINGS

Device Type	Repetitive Peak Off-State Voltage (T_J = +125°C) V_{DRM}, V_{RRM} Volts	Non-Repetitive Peak Reverse Blocking Voltage V_{RSM} Volts
Turn-Off Time = 15 μs Max		
MCR380B -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
-70	700	800
-80	800	900
Turn-Off Time = 20 μs Max		
MCR380C -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
-70	700	800
-80	800	900
-90	900	1000
-100	1000	1100
Turn-Off Time = 30 μs Max		
MCR380D -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
-70	700	800
-80	800	900
-90	900	1000
-100	1000	1100
-110	1100	1200
-120	1200	1300



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
H	2.54	–	0.100	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.065

CASE 220-03

This is advance information on a new introduction and specifications are subject to change without notice.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Average Forward Current, $T_C = 60^oC$ (180° Conduction Angle)	$I_{T(AV)}$	250	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)	I_{TSM}	3500	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.5 – 8.3 ms)	I^2t	50,000	A^2s
Peak Gate Power	P_{GFM}	15	Watts
Average Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Force	–	1000 ± 200	lbs
Critical Rate-of-Rise of On-State Current – Repetitive Non-Repetitive	di/dt	200 1000	Amp/μs

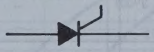
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.095	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)		I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)		I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Duty Cycle ≤ 0.01%, T_J = 25°C)		V_{TM}	–	–	2.65	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)		I_H	–	50	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 ohms, T_J = 125°C)		V_{GDM}	0.15	–	–	Volts
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); Rated V_{DRM}, T_J = +125°C, di_R/dt = 20 A/μs; Repetition Rate = 1.0 pps, I_{TM} = 250 A; dv/dt = 20 V/μs)	MCR380B MCR380C MCR380D	t_q	– – –	– – –	15 20 30	μs
Transient Turn-On Voltage (V_{DRM} = 100 V, I_{TM} = 300 A, PW = 8.0 μs, Gate Drive = 600 mA, rise = 0.1 μs, test point = 4.0 μs)	MCR380B MCR380C MCR380D	V_{TO}	– – –	– – –	5.0 8.0 8.0	Volts
Critical Exponential Rate of Rise (Rated V_{DRM}, Gate open, T_J = 125°C)		dv/dt	200	–	–	V/μs

MCR406-1 (SILICON)
thru
MCR406-4



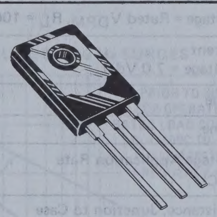
PLASTIC THYRISTORS

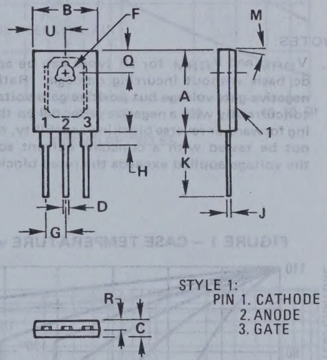
. . . Annular PNPN devices designed for high volume consumer applications, such as temperature, light, and speed control, process and remote control, and warning systems where reliability of operation is important. Sensitive gate trigger permits operation as a switch directly from low level sensors.

- Annular Passivated Surface for Reliability and Uniformity
- True Power Rated — 4.0 Amp @ $T_C = 97^oC$
- Low Level Gate Characteristics — $I_{GT} = 200\ \mu A$ @ $T_A = 25^oC$
- Higher Surge Current Rating — $I_{TSM} = 30$ Amp
- Flat, Rugged, Thermopad†† Construction — for Low Thermal Resistance, High Heat Dissipation, and Durability

PLASTIC SILICON CONTROLLED RECTIFIERS

4.0 AMPERES RMS
30 thru 200 VOLTS





STYLE 1:
PIN 1. CATHODE
2. ANODE
3. GATE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

CASE 90-05

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1)	V_{RRM}		Volts
MCR406-1		30	
MCR406-2		60	
MCR406-3		100	
MCR406-4		200	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Peak Forward Surge Current (1/2 cycle, 60 Hz, T_J = -40 to +110°C)	I_{TSM}	30	Amp
Circuit Fusing Considerations (T_J = -40 to 110°C, t = 1.0 to 8.3 ms)	I^2t	3.6	A^2s
Peak Gate Power — Forward	P_{GFM}	0.5	Watt
Average Gate Power — Forward	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current — Forward	I_{GFM}	0.2	Amp
Peak Gate Voltage — Reverse	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	-40 to +110	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 screw) (Note 2)	—	8	in. lb.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) Note 1	MCR406-1 MCR406-2 MCR406-3 MCR406-4	V_{DRM}	30 60 100 200	– – – –	– – – –	Volts
Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 110°C)		I_{DRM}	–	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 110°C)		I_{RRM}	–	–	100	μA
Forward "On" Voltage (I_{TM} = 4.0 A peak)		V_{TM}	–	–	2.2	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		I_{GT}	–	–	200	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		V_{GT}	–	–	0.8	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms, T_J = 110°C)		V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc)		I_H	–	–	3.0	mA
Turn-On Time		t_{on}	Circuit Dependent. Consult Manufacturer.			
Turn-Off Time		t_{off}				
Forward Voltage Application Rate (T_J = 110°C)		dv/dt	–	10	–	V/μs
Thermal Resistance, Junction to Case		θ_{JC}	–	–	2.0	°C/W
Thermal Resistance, Junction to Ambient		θ_{JA}	–	–	50	°C/W

NOTES:

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

FIGURE 1 – CASE TEMPERATURE versus CURRENT

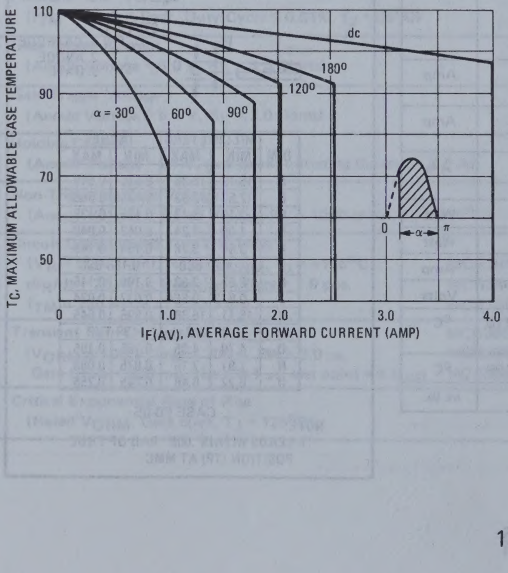


FIGURE 2 – AMBIENT TEMPERATURE versus CURRENT

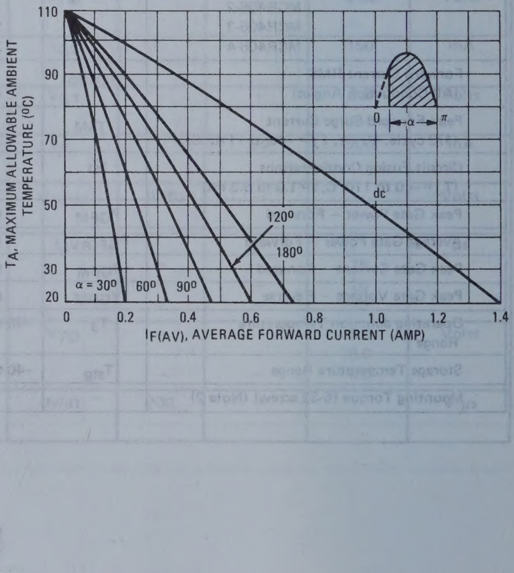


FIGURE 3 – FORWARD CONDUCTION CHARACTERISTICS

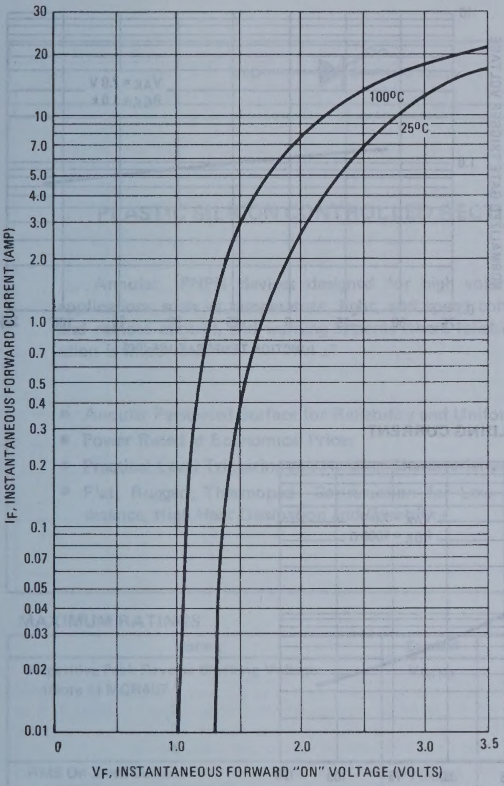


FIGURE 4 – P_D, POWER DISSIPATION

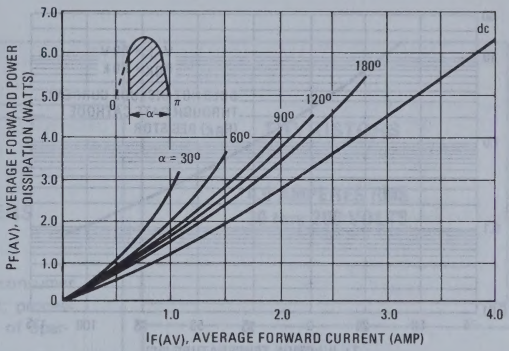


FIGURE 5 – 60 Hz SURGES

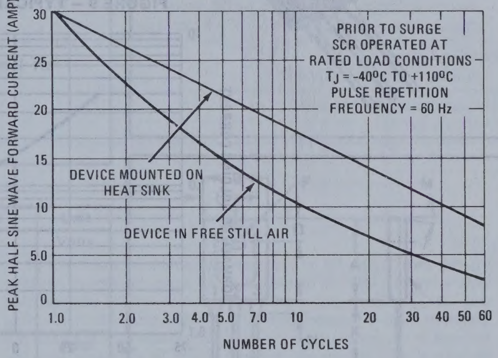


FIGURE 6 – THERMAL RESPONSE

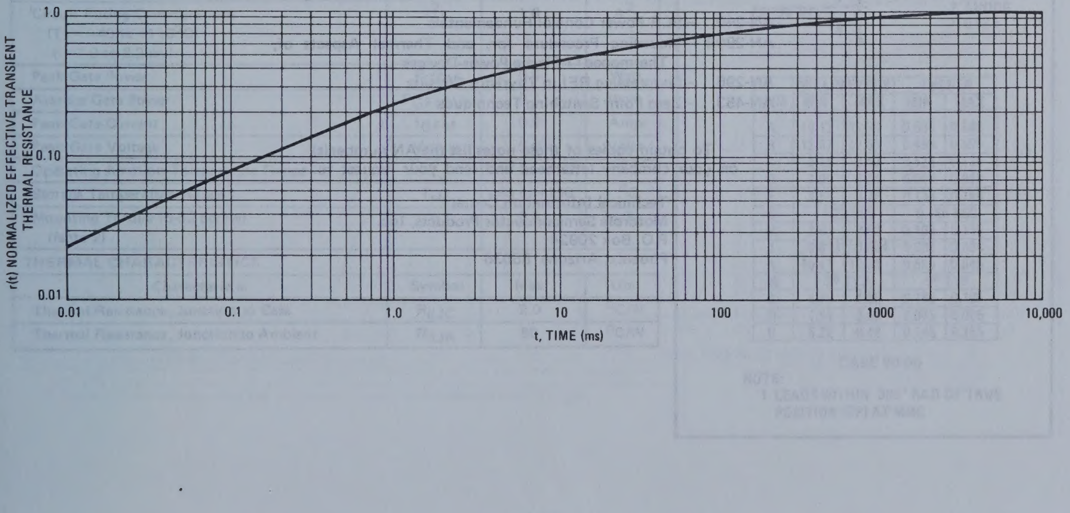


FIGURE 7 — TYPICAL GATE TRIGGER CURRENT

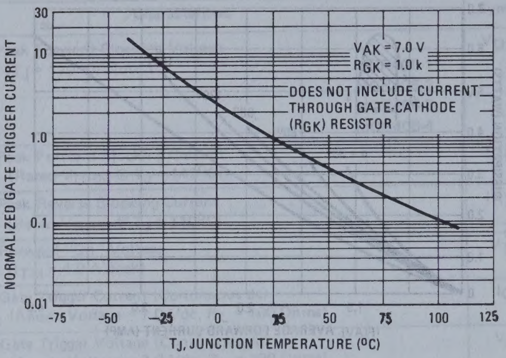


FIGURE 8 — TYPICAL GATE TRIGGER VOLTAGE

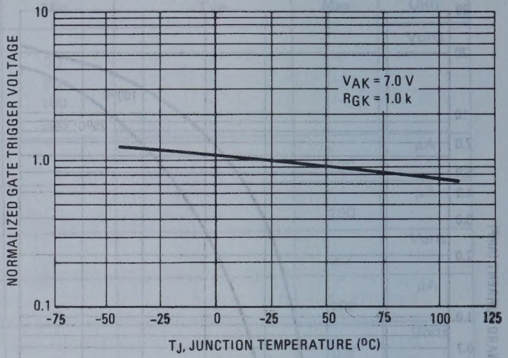
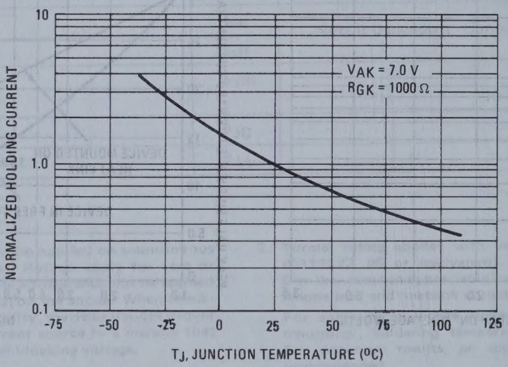


FIGURE 9 — TYPICAL HOLDING CURRENT



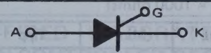
SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-240	— SCR Power Control Fundamentals
AN-290B	— Mounting Procedure for, and Thermal Aspects of, Thermopad†† Plastic Power Devices
AN-295	— Suppressing RFI in Thyristor Circuits
AN-453	— Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

MCR407-1 (SILICON)
thru
MCR407-4



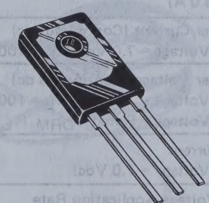
PLASTIC SILICON CONTROLLED RECTIFIERS

. . . Annular PNPN devices designed for high volume consumer applications such as temperature, light, and speed control; process and remote control, and warning systems where reliability of operation is important.

- Annular Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction--for Low Thermal Resistance, High Heat Dissipation and Durability

THYRISTORS

4.0 AMPERES RMS
30 thru 200 VOLTS

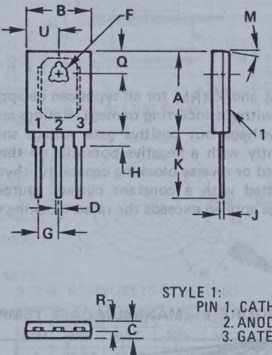


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage (Note 1) MCR407-1 -2 -3 -4	V_{RRM}	 30 60 100 200	Volts
RMS On-State Current (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Average On-State Current (T_C = 89°C)	$I_{T(AV)}$	2.55	Amp
Peak Non-Repetitive Surge Current (One cycle, 60 Hz, T_J = -40 to +110°C)	I_{TSM}	20	Amp
Circuit Fusing Considerations (T_J = -40 to +110°C) t = 1.0 to 8.3 ms)	I^2t	1.6	A^2s
Peak Gate Power	P_{GFM}	0.5	Watt
Average Gate Power	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current	I_{GFM}	0.2	Amp
Peak Gate Voltage	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	-40 to +110	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 Screw) (Note 2)	—	8.0	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	50	°C/W



STYLE 1:
PIN 1. CATHODE
2. ANODE
3. GATE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

CASE 90-05

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) Note 1	V_{DRM}				Volts
MCR407-1		30	–	–	
-2		60	–	–	
-3		100	–	–	
-4		200	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 100°C)	I_{DRM}	–	–	100	µA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 110°C)	I_{RRM}	–	–	100	µA
Peak On-State Voltage (I_{TM} = 4.0 A)	V_{TM}	–	–	2.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms)	I_{GT}	–	–	500	µA
Gate Trigger Voltage (Continuous dc)	V_{GT}				Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms)		–	–	1.0	
(Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C)		0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc)	I_H	–	–	5.0	mA
Forward Voltage Application Rate (T_J = 110°C)	dv/dt	–	10	–	V/µs

NOTES:

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

CURRENT DERATING

FIGURE 1 – MAXIMUM CASE TEMPERATURE

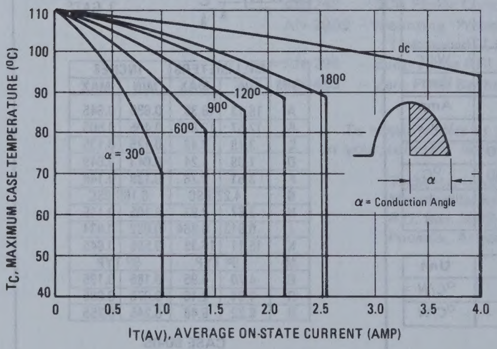
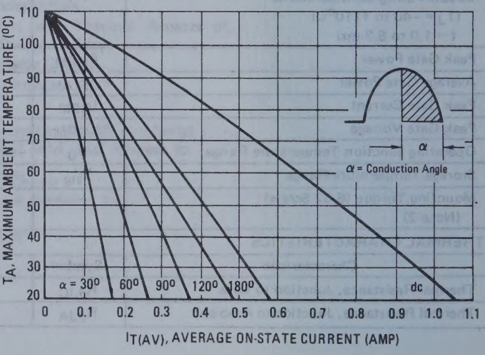


FIGURE 2 – MAXIMUM AMBIENT TEMPERATURE



MCR470 SERIES (SILICON)

BEAM-FIRED INTEGRATED GATE SILICON CONTROLLED RECTIFIERS

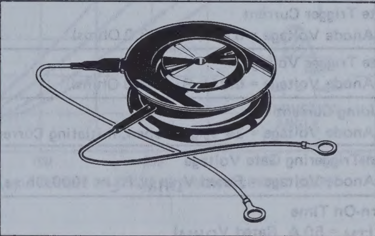
. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed. In addition, the entire series employs the unique Beam-Fired gate design to allow high di/dt and to reduce turn-on losses.

- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/µs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/µs (Min)
- Low Switching Losses
- Integrated Gate Permits Soft-Fire Gate Control

*With 0.05 µF and 20 ohm snubber circuit.

BEAM-FIRED INTEGRATED GATE THYRISTORS

470 AMPERES RMS
100 thru 1500 VOLTS



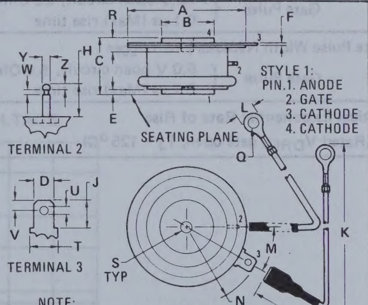
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = +125°C) MCR470 –	$V_{DRM(1)}$		Volts
– 10		100	
– 20		200	
– 30		300	
– 40		400	
– 50		500	
– 60		600	
– 70		700	
– 80		800	
– 90		900	
–100		1000	
–110		1100	
–120		1200	
–130		1300	
–140		1400	
–150		1500	
Non-Repetitive Peak Reverse Block Voltage (t ≤ 5.0 ms) MCR470 –	V_{RSM}		Volts
– 10		200	
– 20		300	
– 30		400	
– 40		500	
– 50		600	
– 60		720	
– 70		840	
– 80		960	
– 90		1080	
–100		1200	
–110		1300	
–120		1450	
–130		1550	
–140		1650	
–150		1800	
Average Forward Current (180° Conduction Angle, T_C = 75°C)	$I_{T(AV)}$	300	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)	I_{TSM}	5500	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C) (t = 1.5 ms) (t = 8.3 ms)	I^2t	50,000 120,000	A^2s
Peak Forward Gate Power	P_{GFM}	15	Watts
Average Forward Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Force	–	1000	lbs.
Critical Rate-of-Rise of On-State Current during Turn – On Interval (Non-Repetitive Rating)	di/dt	1000	Amp/µs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.08	°C/W

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
H	2.54	–	0.100	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.065

CASE 220-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	–	–	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	–	–	15	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Pulse Width = 8.3 ms, Duty Cycle ≤ 1.0%)	V_{TM}	–	–	1.9	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	–	–	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	–	20	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GDM}	0.15	–	–	Volts
Turn-On Time (I_{TM} = 50 A, Rated V_{DRM}) Gate Pulse { 10 V open circuit, 20 Ohm Source 0.1 μs (Max) rise time	t_{on}	–	2.0	–	μs
Gate Pulse Width Necessary to Trigger Gate Pulse { 5.0 V open circuit, 5.0 Ohm Source 0.1 μs (Max) rise time		–	–	10	μs
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, T_J = 125°C)	dv/dt	200	–	–	V/μs

CURRENT DERATING

(f = 50 to 400 Hz)

FIGURE 1 – SQUARE WAVE

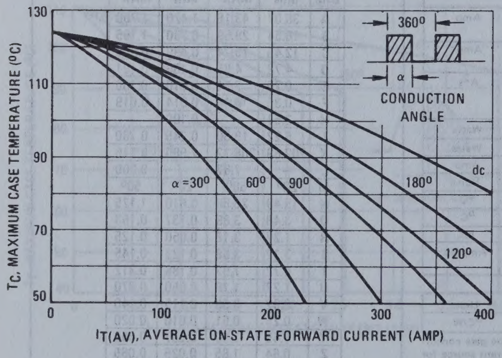


FIGURE 2 – SINE WAVE

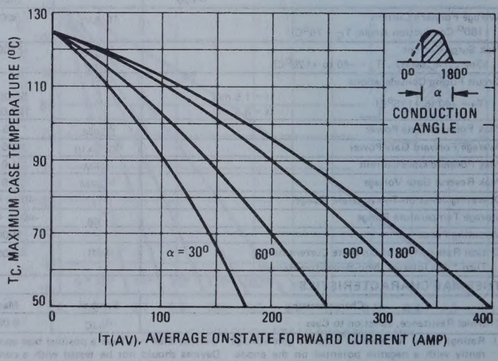


FIGURE 3 – SQUARE WAVE

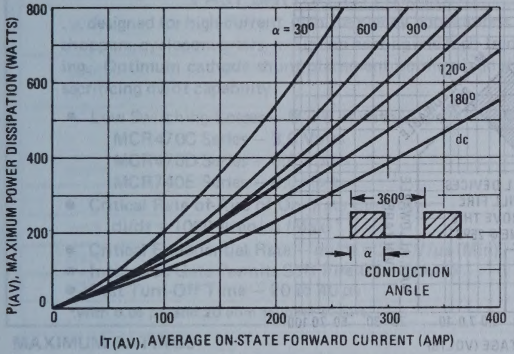


FIGURE 4 – SINE WAVE

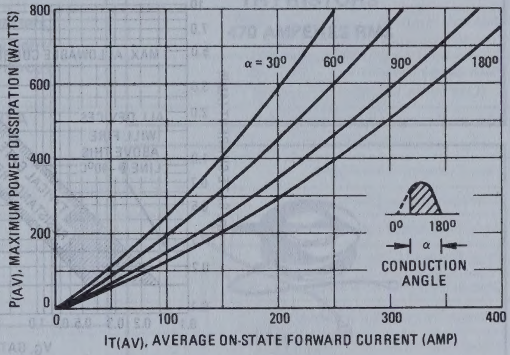


FIGURE 5 – MAXIMUM ON-STATE VOLTAGE

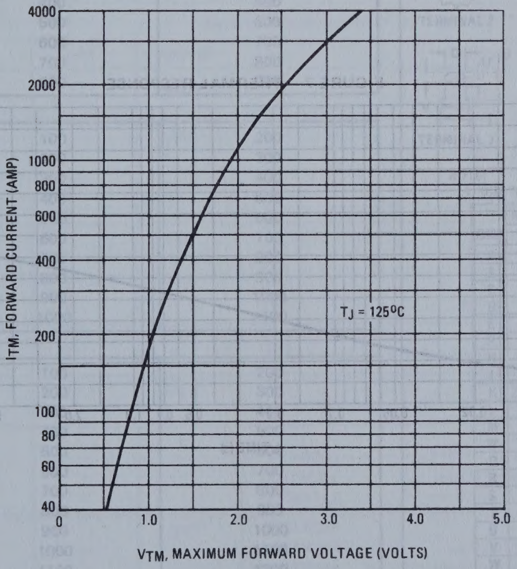


FIGURE 6 — TRIGGERING CHARACTERISTICS

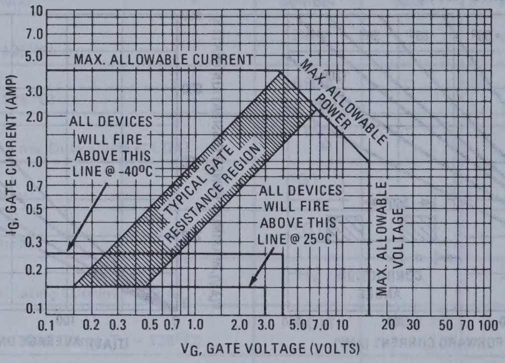
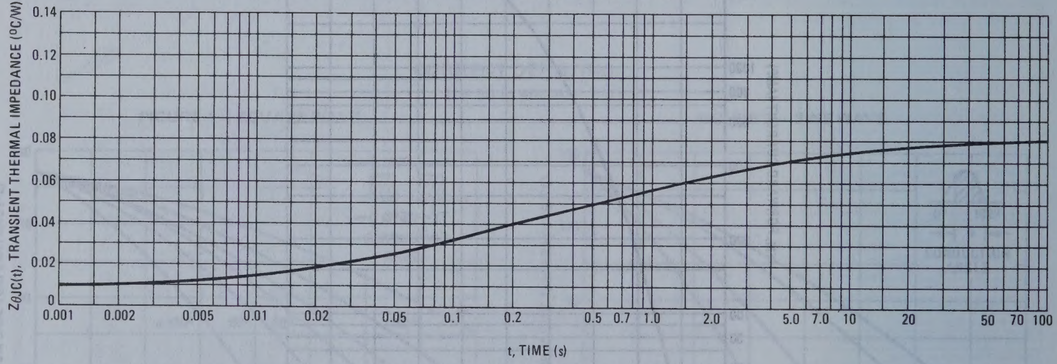


FIGURE 7 — THERMAL RESPONSE



MCR470C SERIES (SILICON)
MCR470D SERIES
MCR470E SERIES

Advance Information

BEAM-FIRED INTEGRATED GATE FAST SWITCH THYRISTORS

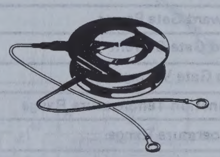
. . . designed for high-current, high-frequency applications in inverters, choppers, cycloconverters, induction heating and high-frequency lighting. Optimum cathode shunt placement permits high di/dt without sacrificing dv/dt capability.

- Low Switching Losses — @ 3.0 µs with 30 µs Pulse, I_P = 150 A
  MCR470C Series — 3.0 Volts
  MCR470D Series — 6.0 Volts
  MCR740E Series — 6.0 Volts
- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/µs (Max)*
- Critical Exponential Rate — dv/dt = 200 V/µs (Min)
- Integrated Gate Permits Soft-Fire Gate Control
- Fast Turn-Off Time — 20 to 40 µs

*With 0.05 µF and 20 ohm snubber circuit.

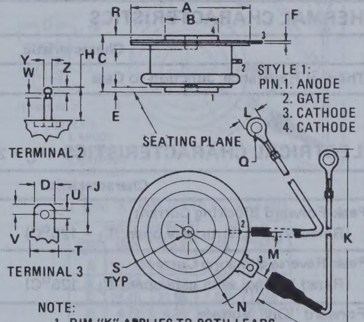
BEAM-FIRED
INTEGRATED GATE
THYRISTORS

470 AMPERES RMS



MAXIMUM RATINGS

Device Type		Repetitive Peak Off-State Voltage (T_J = +125°C) V_{DRM}, V_{RRM} Volts	Non-Repetitive Peak Reverse Blocking Voltage V_{RSM} Volts
Turn-Off Time = 20 µs Max			
MCR470C	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
Turn-Off Time = 30 µs Max			
MCR470D	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
	-90	900	1000
	-100	1000	1100
Turn-Off Time = 40 µs Max			
MCR470E	-10	100	200
	-20	200	300
	-30	300	400
	-40	400	500
	-50	500	600
	-60	600	700
	-70	700	800
	-80	800	900
	-90	900	1000
	-100	1000	1100
	-110	1100	1200
	-120	1200	1300



NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	36.07	43.18	1.420	1.700
B	18.54	29.59	0.730	1.165
C	12.45	15.24	0.490	0.600
D	4.72	4.85	0.186	0.191
E	0.25	2.54	0.010	0.100
F	0.35	0.48	0.014	0.019
H	2.54	–	0.100	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	20°	50°	20°	50°
N	15.49	28.58	0.610	1.125
Q	3.48	3.89	0.137	0.153
R	1.27	3.18	0.050	0.125
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.065

CASE 220-03

This is advance information on a new introduction and specifications are subject to change without notice.

MCR470C series, MCR470D series, MCR470E series (continued)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Average Forward Current, $T_C = 60^oC$ (180°Conduction Angle)	$I_{T(AV)}$	300	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = −40 to +125°C)	I_{TSM}	4500	Amp
Circuit Fusing Considerations (T_J = −40 to +125°C, t = 1.5 - 8.3 ms)	I^2t	84,000	A^2s
Peak Forward Gate Power	P_{GFM}	15	Watts
Average Forward Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	5.0	Volts
Operating Junction Temperature Range	T_J	−40 to +125	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Mounting Force	—	1000 ± 200	lbs
Critical Rate-of-Rise of On-State Current — Repetitive Non-Repetitive	di/dt	200 1000	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.08	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)		I_{DRM}	—	—	15	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)		I_{RRM}	—	—	15	mA
Forward "On" Voltage (I_{TM} = 1000 A Peak, Duty Cycle ≤ 0.01%, T_J = 25°C)		V_{TM}	—	—	2.30	Volts
Gate Trigger Current (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		I_{GT}	—	—	150	mA
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)		V_{GT}	—	—	3.0	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)		I_H	—	50	500	mA
Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)		V_{GSM}	0.15	—	—	Volts
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); Rated V_{DRM}, T_J = +125°C, di_R/dt = 20 A/μs; Repetition Rate = 1.0 pps; I_{TM} = 250 A; dv/dt = 20 V/μs)	MCR470C MCR470D MCR470E	t_q	— — —	— — —	20 30 40	μs
Transient Turn-On Voltage (V_{DRM} = 100 V, I_{TM} = 300 A, PW = 8.0 μs Gate Drive = 600 mA, rise = 0.1 μs, test point = 4.0 μs)	MCR470C MCR470D MCR470E	V_{TO}	— — —	— — —	5.0 8.0 8.0	Volts
Critical Exponential Rate of Rise (Rated V_{DRM}, gate open, T_J = 125°C)		dv/dt	200	—	—	V/μs

MCR550C series
MCR550D series

Advance Information

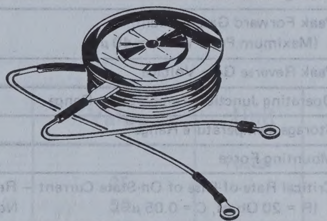
BEAM-FIRED INTEGRATED GATE FAST SWITCHING THYRISTORS

. . . designed for high-current, high-frequency applications in inverters, choppers, cycloconverters, induction heating and high-frequency lighting. Optimum cathode shunt placement permits high di/dt without sacrificing dv/dt capability.

- Critical Rate-of-Rise of On-State Current – di/dt = 1000 Amp/µs (Max)
- Critical Exponential Rate – dv/dt = 200 V/µs (Min)
- Integrated Gate Permits Soft-Fire Gate Control
- Fast Turn-Off Time – 20 and 30 µs

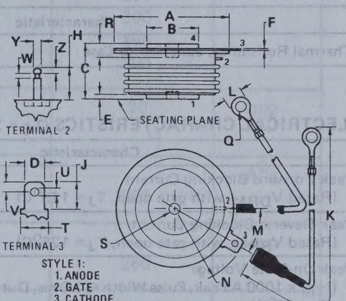
BEAM-FIRED INTEGRATED GATE THYRISTORS

550 AMPERES RMS



MAXIMUM RATINGS

Device Type	Repetitive Peak Off-State Voltage ($T_J = +125^{o}C$) V_{DRM}, V_{RRM} Volts	Non-Repetitive Peak Reverse Blocking Voltage V_{RSM} Volts
Turn-Off Time = 20 µs Max		
MCR550C -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
-70	700	800
-80	800	900
-90	900	1000
-100	1000	1100
Turn-Off Time = 30 µs Max		
MCR550D -10	100	200
-20	200	300
-30	300	400
-40	400	500
-50	500	600
-60	600	700
-70	700	800
-80	800	900
-90	900	1000
-100	1000	1100
-110	1100	1200
-120	1200	1300



STYLE 1:
1. ANODE
2. GATE
3. CATHODE
4. CATHODE

NOTE:
1. DIM "K" APPLIES TO BOTH LEADS

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	55.88	63.50	2.200	2.500
B	26.19	38.10	1.031	1.500
C	25.40	27.05	1.000	1.065
D	4.72	4.85	0.186	0.191
E	0.76	2.79	0.030	0.110
F	0.35	0.48	0.014	0.019
H	3.18	–	0.125	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	15°	50°	15°	50°
N	–	36.45	–	1.435
Q	3.48	3.89	0.137	0.153
R	1.27	4.06	0.050	0.160
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.064

CASE 220-02

This is advance information on a new introduction and specifications are subject to change without notice.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Average On-State Current, $T_C = 60^oC$ (180° Conduction Angle)	$I_{T(AV)}$	350	Amp
Peak Non-Repetitive Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)	I_{TSM}	5500	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C, t = 1.5 — 8.3 ms)	I^2t	120,000	A^2s
Peak Gate Power (Maximum Pulse Width = 40 μs)	P_{GFM}	200	Watts
Average Gate Power	$P_{GF(AV)}$	3.0	Watts
Peak Forward Gate Current (Maximum Pulse Width = 40 μs)	I_{GFM}	4.0	Amp
Peak Reverse Gate Voltage	V_{GRM}	10	Volts
Operating Junction Temperature Range	T_J	-40 to +125	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Force	—	2000 ± 200	lbs
Critical Rate-of-Rise of On-State Current — Repetitive (R = 20 Ohms, C = 0.05 μF) Non-Repetitive	di/dt	200 1000	Amp/μs

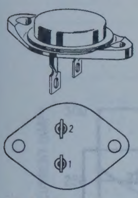
THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.06	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

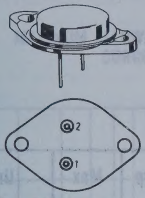
Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)	I_{DRM}	—	—	30	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{RRM}	—	—	30	mA
Peak On-State Voltage (I_{TM} = 1000 A Peak, Pulse Width ⩽ 2.0 ms, Duty Cycle ⩽ 0.01%, T_J = 25°C)	V_{TM}	—	—	2.4	Volts
Gate Trigger Current, Continuous dc (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	—	—	150	mA
Gate Trigger Voltage, Continuous dc (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	V_{GT}	—	—	3.0	Volts
Non-Trigger Gate Voltage (Anode Voltage = Rated V_{DRM}, R_L = 1000 ohms, T_J = 125°C)	V_{GDM}	—	—	0.15	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	—	50	500	mA
Circuit Commutated Turn-Off Time (V_R = 50 V (Min); Rated V_{DRM}, T_J = +125°C, di_R/dt = 20 A/μs; Repetition Rate = 1.0 pps, MCR550C I_{TM} = 250 A; dv/dt = 20 V/μs) MCR550D	t_q	 — —	 — —	 20 30	μs
Transient Turn-On Voltage (V_{DRM} = 100 V, I_{TM} = 300 A, PW = 8.0 μs, Gate Drive = 600 mA, rise = 0.1 μs, test point = 4.0 μs)	V_{TO}	— — —	— — —	 10	Volts
Critical Exponential Rate of Rise of Off-State Voltage (Rated V_{DRM}, Gate open, T_J = 125°C)	dv/dt	200	—	—	V/μs

MCR649-1 thru MCR649-7 (SILICON)



CASE 61
(TO-41)

PIN 1. GATE
2. CATHODE
CASE ANODE



CASE 54
(TO-3 Modified)

PIN 1. ANODE
2. GATE
CASE CATHODE

Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance. For units with pins (TO-3) specify devices MCR649P-1 thru MCR649P-7.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

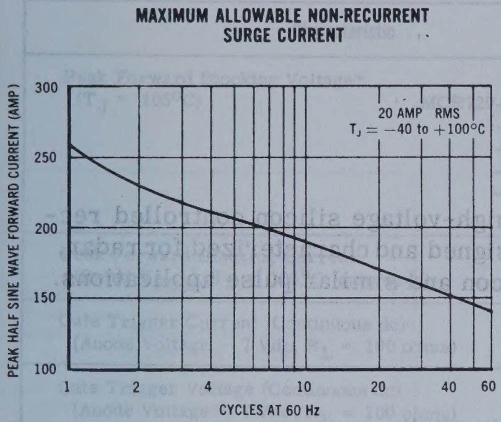
Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	V_{ROM}*		Volts
MCR649-1		25	
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
-7		500	
Forward Current RMS (All Conduction Angles)	I_f	20	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C; t ≤ 8.3 ms)	I^2t	275	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$	260	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

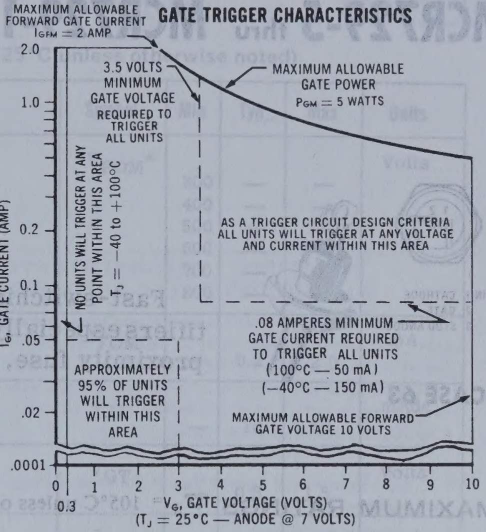
*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage. V_{ROM} ratings apply for zero or negative gate voltage.

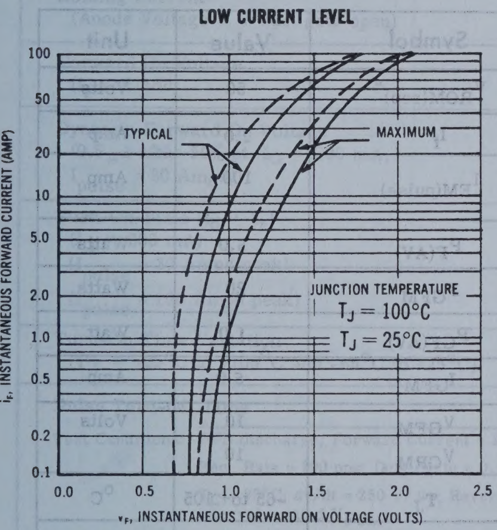
MCR649-1 thru MCR649-7 (continued)

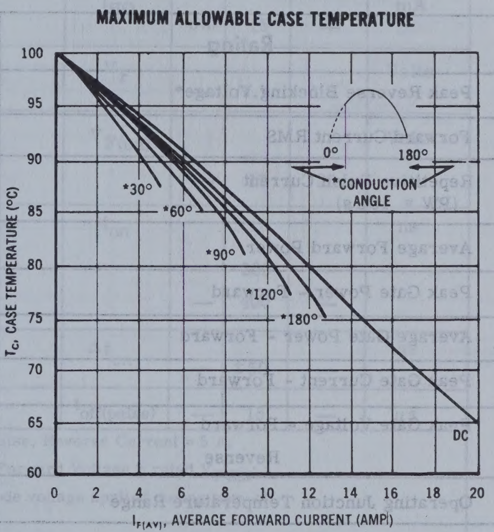
ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

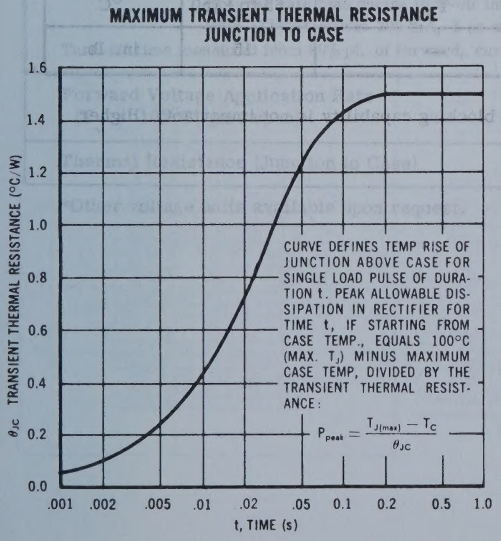
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage ($T_J = 100^oC$)		V_{FOM}				Volts
	MCR649-1		25	—	—	
	-2		50	—	—	
	-3		100	—	—	
	-4		200	—	—	
	-5		300	—	—	
	-6		400	—	—	
	-7		500	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, $T_J = 100^oC$)		I_{FOM}	—	—	5.0	mA
Peak Reverse Blocking Current (Rated V_{FOM} with gate open, $T_J = 100^oC$)		I_{ROM}	—	—	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)		I_{GT}	—	30	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)		V_{GT}	—	1.0	3.5	Volts
(Anode Voltage = Rated V_{FOM}, $R_L = 50\Omega$, $T_J = 100^oC$)		V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Forward On Voltage ($I_F = 20$ Adc)		V_F	—	1.1	1.5	Volts
Turn-On Time ($t_d + t_r$) ($I_G = 50$ mA, $I_F = 10$ A)		t_{on}	—	1.0	—	μs
Turn-Off Time ($I_F = 10$ A, $I_R = 10$ A, dv/dt = 20 V/ μs min, $T_J = 100^oC$) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)		t_{off}	—	25	—	μs
Forward Voltage Application Rate (Gate open, $T_J = 100^oC$)		dv/dt				V/ μs
	MCR649-1 thru MCR649-4		—	20	—	
	MCR649-5 thru MCR649-7		—	30	—	
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	1.5	$^oC/W$

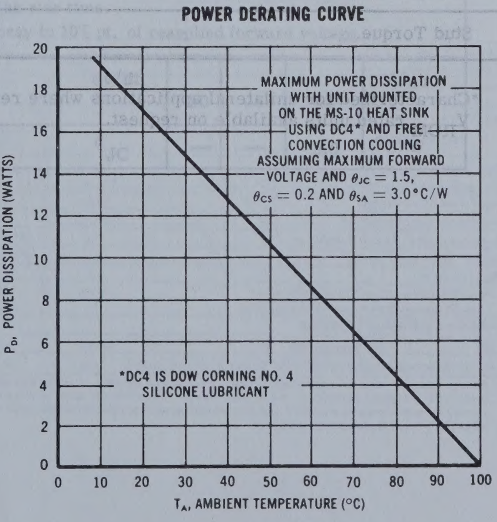

MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT


GATE TRIGGER CHARACTERISTICS

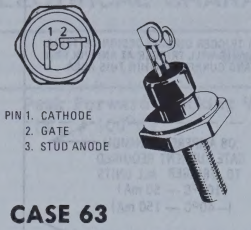

LOW CURRENT LEVEL


MAXIMUM ALLOWABLE CASE TEMPERATURE


MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE


POWER DERATING CURVE

MCR729-5 thru MCR729-10 (SILICON)



CASE 63

Fast-switching, high-voltage silicon controlled rectifiers especially designed and characterized for radar, proximity fuse, beacon and similar pulse applications.

MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}{}^{*}$	50	Volts
Forward Current RMS	I_f	2.0	Amp
Repetitive Pulse Current (PW = 10 µs)	$I_{FM(pulse)}$	100	Amp
Average Forward Power	$P_{F(AV)}$	5.0	Watts
Peak Gate Power - Forward	P_{GFM}	20	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current - Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to+ 105	°C
Storage Temperature Range	T_{stg}	-65 to + 150	°C
Stud Torque	—	15	in. lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher V_{ROM} rated units available on request.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 105°C) MCR729-5	V_{FOM}*	300	—	—	Volts
-6		400	—	—	
-7		500	—	—	
-8		600	—	—	
-9		700	—	—	
-10		800	—	—	
Peak Forward Blocking Current (Rated V_{FOM}, T_J = 105°C, gate open)	I_{FOM}	—	0.2	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)	I_{GT}	—	10	50	mAdc
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)	V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, gate open)	I_{HO}	5.0	15	—	mA
Forward On Voltage (I_f = 2 Adc)	V_F	—	1.1	1.5	Volts
Dynamic Forward On Voltage (0.5 μs after 50% pt, I_G = 200 mA, I_{pulse} = 30 Amps)	$V_{F(on)}$	—	15	25	Volts
Turn-On Time (t_d + t_r) (I_G = 200 mA) (I_{pulse} = 30 Amps peak)	t_{on} —	—	200	—	ns
(I_{pulse} = 100 Amps peak)		—	400	—	
Turn-On Time Variation (T_J = +25°C to +105°C and -65°C to +25°C)	Δt_{on}	—	±50	—	ns
Pulse Turn-Off Time	$t_{off(pulse)}$	—	15	—	μs
Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5 A; Rep. Rate = 100 pps; Duty cycle = 0.05%; Forward Voltage = rated V_{FOM}; T_C = 85°C; dv/dt = 250 V/μs; Reverse anode voltage applied during turn-off interval = rated V_{FOM}; Reverse gate bias during turn-off interval = -6 V; Gate Trigger Pulse: 200 mA, 1 μs wide, 2 ns rise time. Turn-off time measured from 90% pt. of forward, current decay to 10% pt. of reapplied forward voltage.					
Forward Voltage Application Rate (T_J = 105°C, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3.0	°C/W

*Other voltage units available upon request.

MCR800 series (SILICON)

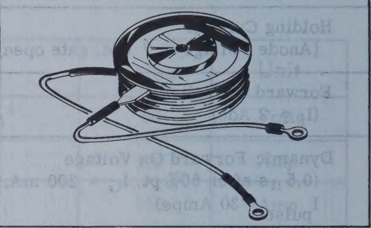
BEAM-FIRED INTEGRATED GATE SILICON CONTROLLED RECTIFIERS

. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed. In addition, the entire series employs the unique Beam-Fired gate design to allow high di/dt and to reduce turn-on losses.

- Critical Rate-of-Rise of On-State Current — di/dt = 1000 Amp/μs (Max)(2)
- Critical Exponential Rate-of-Rise of Off-State Voltage — dv/dt = 200 V/μs (Min)
- Low Switching Losses
- Integrated Gate Permits Soft-Fire Gate Control

BEAM-FIRED
INTEGRATED GATE
THYRISTORS

800 AMPERES RMS
100 thru 1500 VOLTS



MAXIMUM RATINGS

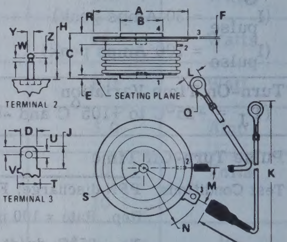
Rating		Symbol	Value	Unit
Repetitive Peak Off-State Voltage (T_J = +125°C) MCR800–		$V_{DRM(1)}$		Volts
	– 10		100	
	– 20		200	
	– 30		300	
	– 40		400	
	– 50		500	
	– 60		600	
	– 70		700	
	– 80		800	
	– 90		900	
	–100		1000	
	–110		1100	
	–120		1200	
	–130		1300	
	–140		1400	
	–150		1500	
Non-Repetitive Peak Reverse Block Voltage (t ⩽ 5.0 ms) MCR800–		V_{RSM}		Volts
	– 10		200	
	– 20		300	
	– 30		400	
	– 40		500	
	– 50		600	
	– 60		720	
	– 70		840	
	– 80		960	
	– 90		1080	
	–100		1200	
	–110		1300	
	–120		1450	
	–130		1550	
	–140		1650	
	–150		1800	
Average On-State Current (180° Conduction Angle, T_C = 75°C)		$I_{T(AV)}$	500	Amp
Peak Surge Current (One cycle, 60 Hz, T_J = -40 to +125°C)		I_{TSM}	7000	Amp
Circuit Fusing Considerations (T_J = -40 to +125°C)	(t = 1.5 ms) (t = 8.3 ms)	I^2t	100,000 200,000	A^2s
Peak Forward Gate Power		P_{GFM}	25	Watts
Average Forward Gate Power		$P_{GF(AV)}$	5.0	Watts
Peak Forward Gate Current		I_{GFM}	6.0	Amp
Peak Reverse Gate Voltage		V_{GRM}	10	Volts
Operating Junction Temperature Range		T_J	-40 to +125	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Mounting Force		–	2000	lbs.
Critical Rate-of-Rise of On-State Current during Turn-On Interval (Non-Repetitive Rating) (2)		di/dt	1000	Amp/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.06	°C/W

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) With 0.05 μF and 20 ohm snubber circuit.



STYLE 1:
1. ANODE
2. GATE
3. CATHODE
4. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	55.88	63.50	2.200	2.500
B	26.19	38.10	1.031	1.500
C	25.40	27.05	1.000	1.065
D	4.72	4.85	0.186	0.191
E	0.76	2.79	0.030	0.110
F	0.35	0.48	0.014	0.019
H	3.18	–	0.125	–
J	6.22	19.30	0.245	0.760
K	202.69	206.12	7.980	8.115
L	–	7.62	–	0.300
M	15°	50°	15°	50°
N	–	36.45	–	1.435
Q	3.48	3.89	0.137	0.153
R	1.27	4.06	0.050	0.160
S	3.12	3.68	0.123	0.145
T	4.72	7.92	0.186	0.312
U	1.27	1.78	0.050	0.070
V	2.92	3.56	0.115	0.140
W	0.25	0.51	0.010	0.020
Y	1.45	1.50	0.057	0.059
Z	0.64	1.65	0.025	0.064

CASE 220-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward and Reverse Blocking Current (Rated V_{DRM}, with gate open) (Rated V_{RRM}, with gate open, T_J = 125°C)	I_{DRM} I_{RRM}	— —	— —	15 30	mA
Peak On-State Voltage (I_{TM} = 1000 A Peak, Pulse Width = 8.3 ms, Duty Cycle ≤ 1.0%)	V_{TM}	—	—	1.55	Volts
Gate Trigger Current, Continuous dc (Anode Voltage = 6.0 V, R_L = 3.0 Ohms)	I_{GT}	—	—	150	mA
Gate Trigger Voltage, Continuous dc (Anode Voltage = 6.0 V, R_L = 3.0 Ohms) (Anode Voltage = Rated V_{DRM}, R_L = 1000 Ohms, T_J = 125°C)	V_{GT}	— 0.15	— —	3.0 —	Volts
Holding Current (Anode Voltage = 24 V, gate open, Initiating Current = 2.0 A)	I_H	—	100	500	mA
Gate Controlled Turn-On Time (I_{TM} = 50 A, Rated V_{DRM}) Gate Pulse { 10 V open circuit, 20 Ohm Source 0.1 µs (Max) rise time	t_{gt}	—	4.0	—	µs
Gate Pulse Width Necessary to Trigger Gate Pulse { 5.0 V open circuit, 5.0 Ohm Source 0.1 µs (Max) rise time		—	—	10	µs
Critical Exponential Rate of Rise of Off-State Voltage (Rated V_{DRM}, gate open, T_J = 125°C)	dv/dt	200	—	—	V/µs

CURRENT DERATING

(f = 50 to 400 Hz)

FIGURE 1 — SQUARE WAVE

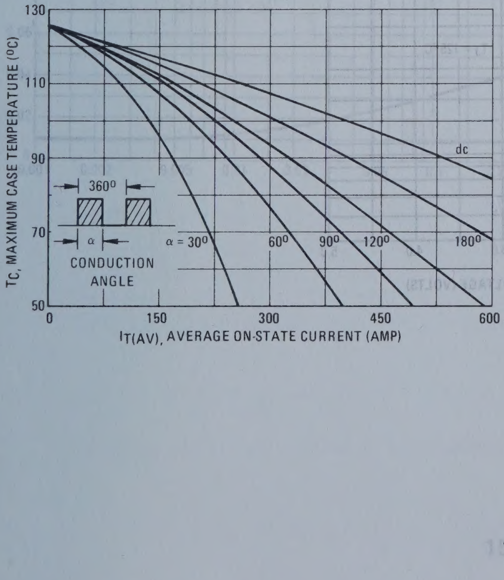
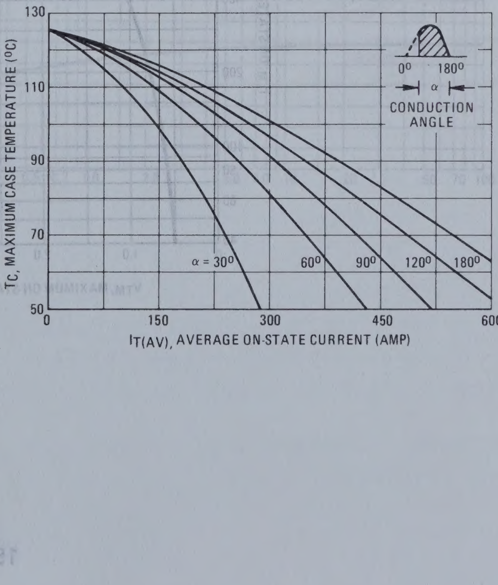


FIGURE 2 — SINE WAVE



FORWARD POWER DISSIPATION

FIGURE 3 – SQUARE WAVE

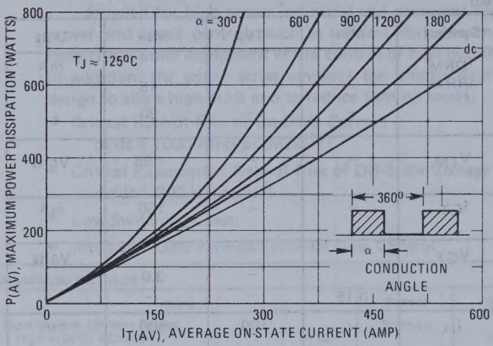


FIGURE 4 – SINE WAVE

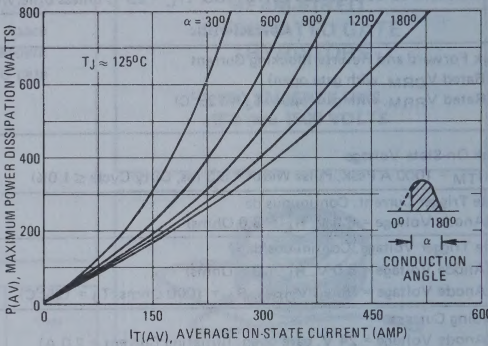


FIGURE 5 – MAXIMUM ON-STATE VOLTAGE

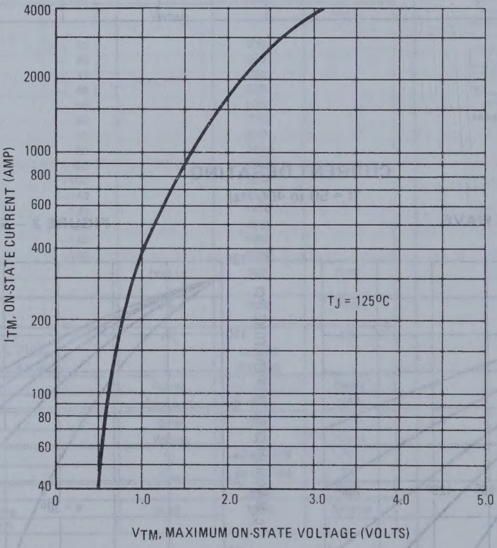


FIGURE 6 – TRIGGERING CHARACTERISTICS

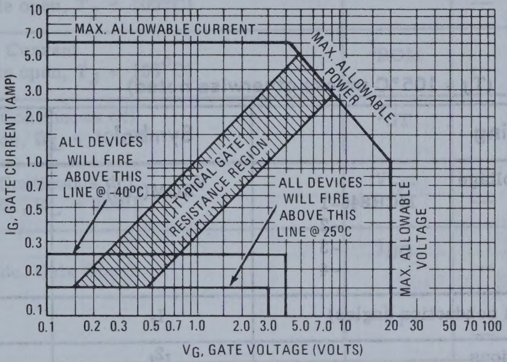
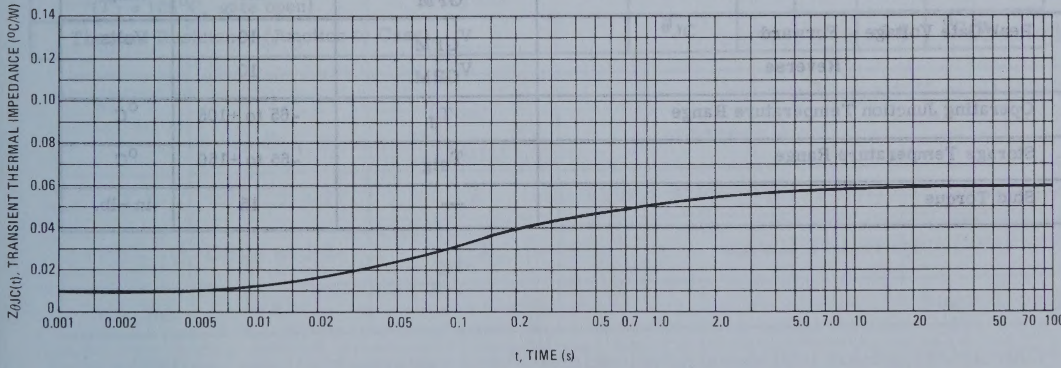
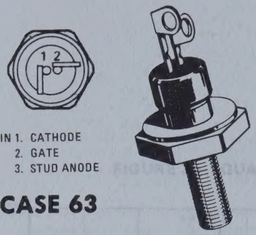


FIGURE 7 – THERMAL RESPONSE



MCR846 series (SILICON)



PIN 1. CATHODE
2. GATE
3. STUD ANODE

CASE 63

Silicon controlled rectifiers for low-power switching and control applications requiring blocking to 200 volts and load currents to 2 amp.

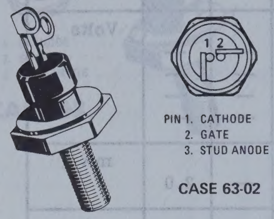
MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage	$V_{ROM(rep)}$		Volts
MCR846-1		25	
-2		50	
-3		100	
-4		200	
Forward Current RMS (all conduction angles)	I_f	2.0	Amp
Circuit Fusing Considerations (T_J = -65 to +105°C; t ≦ 8.3 ms)	I^2t	35	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +105°C)	$I_{FM(surge)}$	30	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	15	in - lb.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 105°C) MCR846-1 -2 -3 -4	V_{FOM}	 25 50 100 200	 — — — —	 — — — —	Volts
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 105°C)	I_{FOM}	—	—	2.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 105°C)	I_{ROM}	—	—	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100Ω)	I_{GT}	—	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100Ω)	V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	15	—	mA
Forward On Voltage (I_F = 2 Adc)	V_F	—	1.3	1.6	Volts
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 2 A)	t_{on}	—	0.5	—	μs
Turn-Off Time (I_F = 2 A, I_R = 10 A, dv/dt = 50 V/μs) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	6.0	—	μs
Forward Voltage Application Rate (T_J = 105°C, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3.0	°C/W

MCR1336-5 (SILICON)
thru
MCR1336-10



CASE 63-02

Fast switching, high-voltage thyristors especially designed for pulse modulator applications in radar and other similar equipment.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* ($T_J = 105°C$)	$V_{ROM(rep)}$*	50	Volts
Repetitive Peak Forward Current (PW = 3.0 µs, Duty Cycle = 0.6%, T_C = 85° C max)	$I_{FM(rep)}$	300	Amp
Current Application Rate**	di/dt**	1000	A/µs
Peak Gate Power-Forward	P_{GFM}	20	Watts
Average Gate Power-Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current-Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage-Forward Reverse***	V_{GFM} V_{GRM}***	7.0 7.0	Volts
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque	-	15	in. lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher voltage units available upon request. $V_{ROM(rep)}$ may be applied as a continuous dc voltage for zero or negative gate voltage but positive gate voltage must not be applied concurrently with a negative potential on the anode. When checking blocking capability, do not permit the applied voltage to exceed the rated voltage.

**Minimum Gate Trigger Pulse: i_G = 500 mA, PW = 1.0 µs, t_r = 20 ns.

***Do not reverse bias gate during forward conduction if anode current exceeds 10 amperes.

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage* ($T_C = 105^\circ C$) MCR1336 -5 -6 -7 -8 -9 -10	V_{FOM}*	 300 400 500 600 700 800	 - - - - - -	 - - - - - -	Volts
Peak Forward and Reverse Blocking Current (Rated V_{FOM} and V_{ROM}, $T_C = 105^\circ C$, gate open)	I_{FOM} I_{ROM}	- -	- -	2.0 2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, $T_C = 25^\circ C$) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, $T_C = -65^\circ C$)	I_{GT}	 - -	 - -	 40 100	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = rated V_{FOM}, R_L = 100 ohms, $T_C = 105^\circ C$) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, $T_C = 25^\circ C$) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, $T_C = -65^\circ C$)	V_{GT}	 0.2 - -	 - - -	 - 1.25 2.0	Volts
Holding Current (Anode Voltage = 7.0 Vdc, gate open, $T_C = 105^\circ C$) (Anode Voltage = 7.0 Vdc, gate open, $T_C = 25^\circ C$)	I_{HO}	 1.0 -	 - -	 - 50	mA
Forward "On" Voltage (I_f = 1.0 Adc, PW = 1.0 ms max, Duty cycle ≤ 1.0%)	V_F	-	-	2.0	Volts
Dynamic Forward "On" Voltage (0.5 μs after 50% decay point on dynamic forward voltage waveform) Forward Current: 100 A pulse (PFN discharge circuit) Gate Pulse: at 500 mA, PW = 1.0 μs, t_r = 20 ns	$V_{F(on)}$	-	45	-	Volts
Turn-On Time Delay Time Rise Time Forward Current: 100 A Pulse (Capacitor discharge circuit) Gate Pulse: at 500 mA, PW = 1.0 μs, t_r = 20 ns	 t_d t_r	 - -	 75 75	 - -	ns
Pulse Turn-Off Time Test Conditions: PFN discharge; Forward Current = 100 A pulse; Reverse Current = 5.0 A, $T_C = 85^\circ C$, dv/dt = 250 V/μs to Rated V_{FOM}; Reverse anode voltage during turn-off interval = 0 V; Reverse gate bias during turn-off interval = 6.0 V.	$t_{off(pulse)}$	-	7.0	-	μs
Forward Voltage Application Rate (Linear Rise of Voltage) ($T_C = 105^\circ C$, gate shorted)	dv/dt	250	-	-	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	-	-	2.5	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. When checking forward or reverse blocking capability, these devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage. Other voltage units available upon request.

MCR1718-5 (SILICON)
thru
MCR1718-8

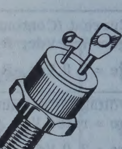
THYRISTORS
SILICON CONTROLLED RECTIFIERS

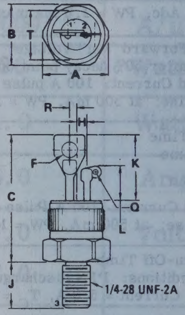
. . . fast switching, high-voltage thyristors especially designed for pulse modulator applications.

- High-Voltage Capability from 300 to 600 Volts
- Repetitive Pulse Current to 1000 Amp
- Pulse Repetition as High as 4000 pps
- Current Application Rate as High as 1000 A/μs

THYRISTORS
PNPN

25 AMPERES RMS
300 thru 600 VOLTS





STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.34	15.60	0.604	0.614
B	14.00	14.20	0.551	0.559
C	26.67	30.23	1.050	1.190
F	3.43	4.06	0.135	0.160
H	2.29 REF		0.090 REF	
J	10.67	11.56	0.420	0.455
K	15.75	17.02	0.620	0.670
L	7.62	8.89	0.300	0.350
Q	1.40	1.65	0.055	0.065
R	1.65 REF		0.065 REF	
T	12.73	12.83	0.501	0.505

CASE 263-02

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage[(1)]	V_{RRM}		Volts
MCR1718-5		300	
-6		400	
-7		500	
-8		600	
Non-Repetitive Peak Reverse Voltage (Transient) (Non-Recurrent 5 ms (max)	V_{RSM}		Volts
MCR1718-5		400	
-6		500	
-7		600	
-8		700	
Forward Current RMS	$I_{T(RMS)}$	25	Amp
Peak Forward Surge Current (1-10 μs Pulse Width)	I_{TSM}	1000	Amp
Current Application Rate (up to 1000 Adc peak)	di/dt	1000	A/μs
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≦ 1.0 ms	I^2t	250	A^2s
Dynamic Average Power (T_C = 65°C)	$P_{F(AV)}$	30	Watts
Peak Gate Power - Forward	P_{GM}	20	Watts
Average Gate Power - Forward	$P_{G(AV)}$	1.0	Watt
Peak Gate Current - Forward	I_{GM}	5.0	Amp
Peak Gate Voltage	V_{GM}	10	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in.-lb

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W

MCR1718-5 thru MCR1718-8 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage [1] (T_J = 125°C) MCR1718-5 -6 -7 -8	V_{DRM}	 300 400 500 600	 – – – –	 – – – –	Volts
Peak Forward Blocking Current (Rated V_{DRM} with gate open, T_J = 125°C)	I_{DRM}	–	–	8.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} with gate open, T_J = 125°C)	I_{RRM}	–	–	8.0	mA
Forward "On" Voltage (I_F = 25 Adc) (I_{GT} = 500 mA, I_{pulse} = 500 Amps) (1.0 µs after start (10% pt.) of I_{pulse}) (5.0 µs after start (10% pt.) of I_{pulse})	V_{TM}	 – – –	 1.1 30 5.0	 1.3 – –	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 50 Ohms)	I_{GT}	–	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 50 Ohms) (Anode Voltage = Rated V_{DRM}, R_L = 500 Ohms, T_J = 125°C)	V_{GT} V_{GD}	 – 0.25	 0.8 –	 1.5 –	Volts
Holding Current (Anode Voltage = 7.0 Vdc, Gate Open) (Anode Voltage = 7.0 Vdc, Gate Open, T_J = 125°C)	I_H	 5.0 –	 15 6.0	 – –	mA
Circuit Commutated Turn-Off Time (I_F = 500 A, I_R = 10 A, dv/dt = 20 V/µs) (Conductive Charging Circuit — Circuit dependent)	t_q	–	20	–	µs
Critical Exponential Rate of Rise (Gate Open, T_J = 125°C)	dv/dt	–	100	–	V/µs

[1] V_{DRM} for all types can be supplied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR1906-1 thru MCR1906-4 (SILICON)

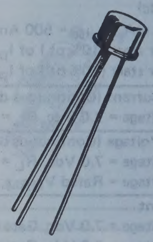
SILICON CONTROLLED RECTIFIERS

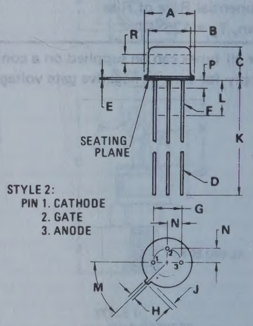
. . . designed for applications in control systems and sensing circuits where low-level gating and holding characteristics are necessary.

- Low-Level Gate Characteristics — I_{GT} = 1.0 mA (Max) @ T_C = 25°C
- Low Holding Current — I_H = 5.0 mA (Max) @ T_C = 25°C
- Anode Common to Case
- Glass-to-Metal Bond for Maximum Hermetic Seal

THYRISTORS
PNPN

1.6 AMPERES RMS
25 thru 200 VOLTS





STYLE 2:
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted.)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1)	V_{RRM}		Volts
MCR1906-1		25	
MCR1906-2		50	
MCR1906-3		100	
MCR1906-4		200	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	1.6	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C) No Repetition Until Thermal Equilibrium is Restored	I_{TSM}	15	Amp
Peak Gate Power-Forward	P_{GM}	0.1	Watt
Average Gate Power-Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current-Forward	I_{GM}	0.1	Amp
Peak Gate Voltage	V_{GM}	6.0	Volt
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (>1/16″ From Case, 10 s max.)	–	+230	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms.)

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (1) MCR1906-1 MCR1906-2 MCR1906-3 MCR1906-4	V_{DRM}	 25 50 100 200	 — — — —	Volt
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 100°C)	I_{DRM}	—	500	μA
Peak Reverse Blocking Current (3) (Rated V_{RRM}, T_J = 100°C)	I_{RRM}	—	500	μA
Forward "On" Voltage (Pulsed, 1.0 ms max, Duty Cycle ≤1.0%) (I_F = 1.0 Adc peak)	V_{TM}	—	1.75	Volt
Gate Trigger Current (2) (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 ohms)	I_{GT}	—	1.0	mAdc
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 ohms) (Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 100°C)	 V_{GT} V_{GD}	 — 0.1	 1.0 —	Volt
Holding Current (Anode Voltage = 7.0 V)	I_H	—	5.0	mA
Turn-On Time	t_{on}	Circuit dependent, consult manufacturer		
Turn-Off Time	t_{off}			

(1) V_{RRM} and V_{DRM} can be applied for all types on a continuous dc basis without incurring damage. Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) R_{GK} current is not included in measurement.

(3) Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

FIGURE 1 – CASE TEMPERATURE versus CURRENT

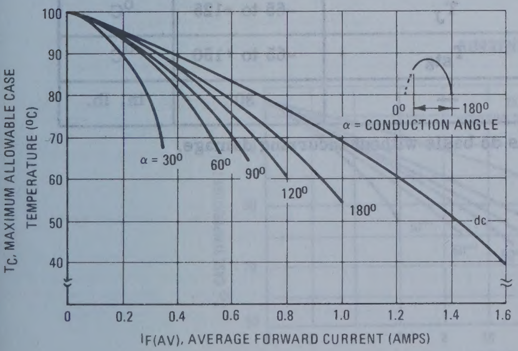
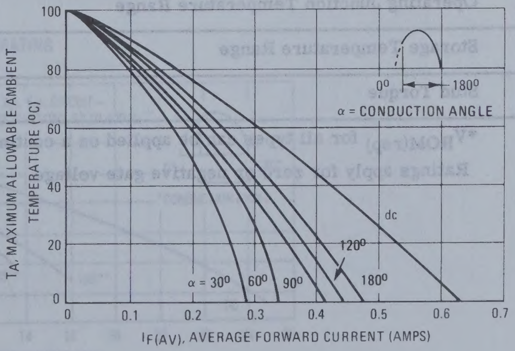
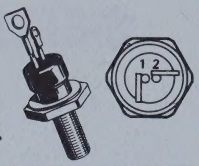


FIGURE 2 – AMBIENT TEMPERATURE versus CURRENT



MCR1907-1 thru MCR1907-6 (SILICON)



PIN 1. CATHODE
2. GATE
3. STUD ANODE

CASE 64
(TO-48)

Fast turn-on, fast turn-off silicon controlled rectifiers for high-frequency applications requiring blocking to 400 volts and load currents to 25 amp.

MAXIMUM RATINGS ($T_J = 125°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* MCR1907-1 -2 -3 -4 -5 -6	$V_{ROM(rep)}$*	 25 50 100 200 300 400	Volts
Peak Reverse Blocking Voltage (Non-Recurrent 5 ms (max.) MCR1907-1 -2 -3 -4 -5 -6	$V_{ROM(non\text{-}rep)}$	 35 75 150 300 400 500	Volts
Forward Current RMS (All Conduction Angles)	I_f	25	Amp
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≦ 8.3 ms)	I^2t	75	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	150	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current — Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 5.0	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in. lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative gate voltage.

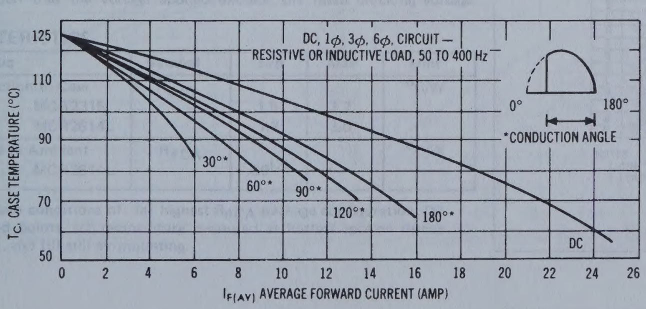
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) MCR1907-1	V_{FOM}*	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
-5		300	—	—	
-6		400	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)	I_{FOM}	—	—	4.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 125°C)	I_{ROM}	—	—	4.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50Ω)	I_{GT}	—	15	30	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	V_{GT}	—	—	1.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 125°C)	V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	12	—	mA
Forward On Voltage (I_F = 20 Adc)	V_F	—	1.4	1.7	Volts
Turn-On Time (I_G = 200 mA, I_F = 10 A)	t_{on}	—	0.5	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 30 V/μs min.) (V_{FXM} = rated voltage) T_J = 125°C (V_{RXM} = rated voltage)	t_{off}	—	—	12	μs
Forward Voltage Application Rate (T_J = 125°C, gate open)	dv/dt	30	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.7	°C/W

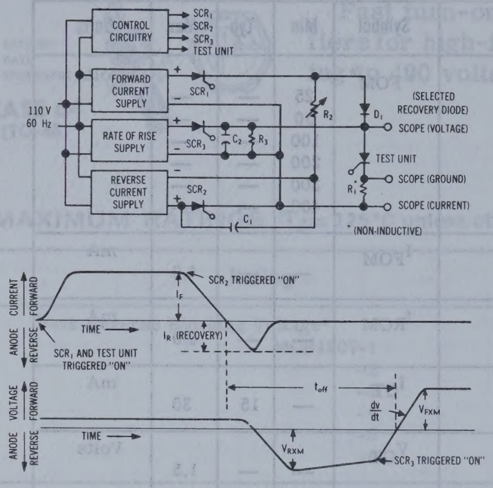
*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative gate voltage. These devices should never be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

CURRENT DERATING



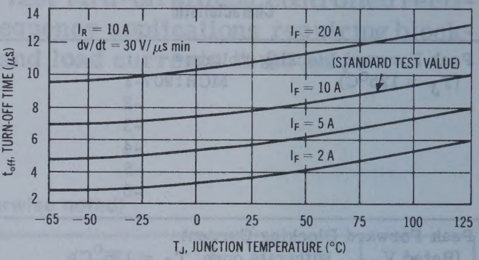
TURN-OFF TIME TEST CIRCUIT †


CONTROL CIRCUITRY
SCR₁
SCR₂
SCR₃
TEST UNIT
FORWARD CURRENT SUPPLY
SCR₁
110 V 60 Hz
RATE OF RISE SUPPLY
SCR₃
C₂
R₃
REVERSE CURRENT SUPPLY
SCR₂
C₁
R₂
D₁
(SELECTED RECOVERY DIODE)
SCOPE (VOLTAGE)
TEST UNIT
R₁
SCOPE (GROUND)
SCOPE (CURRENT)
* (NON-INDUCTIVE)
ANODE CURRENT FORWARD REVERSE
SCR₂ TRIGGERED "ON"
I_F
TIME
I_R (RECOVERY)
SCR₁ AND TEST UNIT TRIGGERED "ON"
ANODE VOLTAGE FORWARD REVERSE
t_off
dv/dt
V_FXM
TIME
V_RXM
SCR₃ TRIGGERED "ON"

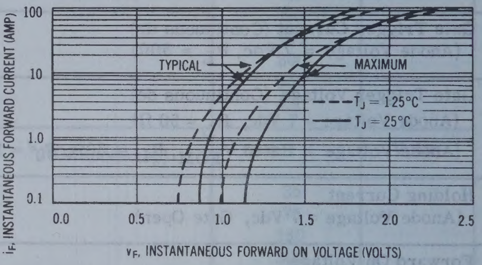
Forward conduction current is passed through the device (SCR_1 and test device triggered on). The anode is then driven negative (SCR_2 triggered on), causing reverse current to flow. The anode-to-cathode potential goes negative with a decrease in reverse current. Forward voltage is then applied to the anode of the device (SCR_3 triggered on). The device has fully recovered when it regains its ability to block the reapplied forward voltage.

† Consult manufacturer for further circuit information.

TYPICAL TURN-OFF TIME versus PEAK FORWARD CURRENT AND JUNCTION TEMPERATURE



FORWARD CONDUCTING CHARACTERISTICS



MCR2315 SERIES (SILICON)
MCR2614L SERIES

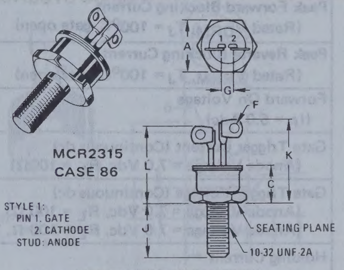
SILICON CONTROLLED RECTIFIERS

. . . designed for applications requiring blocking voltages through 400 volts and rms currents through 8.0 amperes. These devices are available in a choice of space-saving, economical packages for mounting versatility.

- Low Forward Voltage Drop – Typically 1.0 Volt at 5.0 A at 25°C
- Fast, Stable Switching Times – Typically 1.0 μs Turn-On, 12 μs Turn-Off at 25°C
- All-Diffused Junctions for Greater Parameter Uniformity
- Fatigue-Free Solder Construction
- Glass-to-Metal Hermetic Seal

SILICON CONTROLLED RECTIFIERS

8.0 AMPERES RMS
25 thru 400 VOLTS



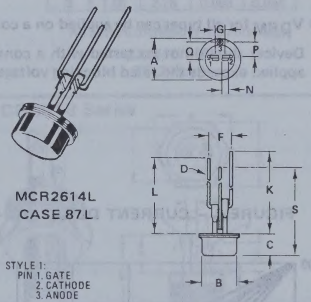
MCR2315
CASE 86

STYLE 1:
PIN 1. GATE
2. CATHODE
STUD: ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.10	–	0.437
C	–	7.87	–	0.310
F	1.78 TYP		0.070 TYP	
G	2.29	2.79	0.090	0.110
J	10.72	11.48	0.422	0.452
K	–	16.76	–	0.660
L	–	15.49	–	0.610

NOTE:
1. DIM "G" MEASURED AT CAN.

CASE 86



MCR2614L
CASE 87L

STYLE 1:
PIN 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	10.92	–	0.430
B	–	8.89	–	0.350
C	–	5.97	–	0.235
D	0.76	0.86	0.030	0.034
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
K	33.53	–	1.320	–
L	31.50 TYP		1.240 TYP	
N	1.65	1.91	0.065	0.075
P	3.43	3.68	0.135	0.145
Q	4.57	5.08	0.180	0.200
S	30.48	–	1.20	–

NOTES:
1. DIM. "G" MEASURED AT CAN.
2. LEAD NO. 3 ±7.5° DISPLACEMENT.

CASE 87L-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (1)	V_{RRM}		Volts
MCR2315 / MCR2614L –1		25	
–2		50	
–3		100	
–4		200	
–5		300	
–6		400	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	8.0	Amp
Peak Forward Surge Current (One cycle, 60 Hz, T_J = -40 to +100°C) Forward Polarity	I_{TSM}	80	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C; t ⩽ 8.3 ms) Forward Polarity	I^2t	40	A^2s
Peak Gate Power – Forward	P_{GM}	5.0	Watts
Average Gate Power – Forward	$P_{GM(AV)}$	0.5	Watt
Peak Gate Current – Forward	I_{GM}	2.0	Amp
Peak Gate Voltage	V_{GM}	10	Volts
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (MCR2315 series)		15	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MCR2315		1.5	2.7	
MCR2614L		1.8	3.0	
Thermal Resistance, Case to Ambient MCR2614L	$R_{\theta CA}$	50[(2)]	–	°C/W

(2) Applies for the worst-case conditions of: (a) highest $R_{\theta CA}$ package configuration, (b) leads terminated at end points, (c) temperature measured at hottest spot on device (center of case bottom), and (d) still air mounting.

ELECTRICAL CHARACTERISTICS ($T_J = 25^oC$ unless otherwise noted)

Apply to all case types unless otherwise noted

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (1) ($T_J = 100^oC$) MCR2315 MCR2614L -1 -2 -3 -4 -5 -6	V_{DRM}	25 50 100 200 300 400	– – – – – –	– – – – – –	Volts
Peak Forward Blocking Current (Rated V_{DRM}, $T_J = 100^oC$, gate open)	I_{DRM}	–	–	3.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, $T_J = 100^oC$, gate open)	I_{RRM}	–	–	3.0	mA
Forward On Voltage (I_F = 5.0 Adc)	V_{TM}	–	1.0	1.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, $R_L = 100\Omega$)	I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$) (Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$, $T_J = 100^oC$)	V_{GT} V_{GD}	– 0.2	0.6 –	1.5 –	Volts
Holding Current (Anode Voltage = 7.0 Vdc, gate open)	I_H	–	10	50	mA
Turn-On Time (I_F = 5.0 Adc, I_{GT} = 20 mAdc)	t_{on}	–	1.0	–	µs
Circuit Commutated Turn-Off Time (I_F = 5.0 Adc, I_R = 5.0 Adc) (I_F = 5.0 Adc, I_R = 5.0 Adc, $T_J = 100^oC$)	t_q	– –	15 30	– –	µs
Critical Exponential Rate of Rise ($T_J = 100^oC$)	dv/dt	–	50	–	V/µs

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

Devices should not be tested with a constant current source for forward or reverse blocking capability in a manner that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING - HALF WAVE

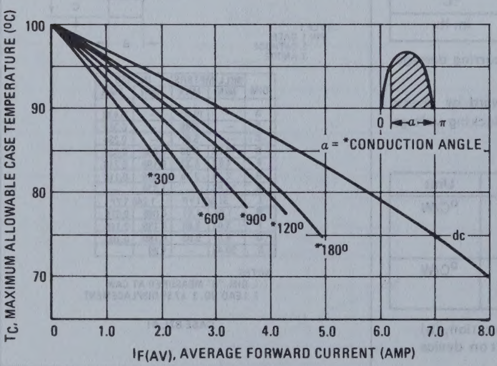
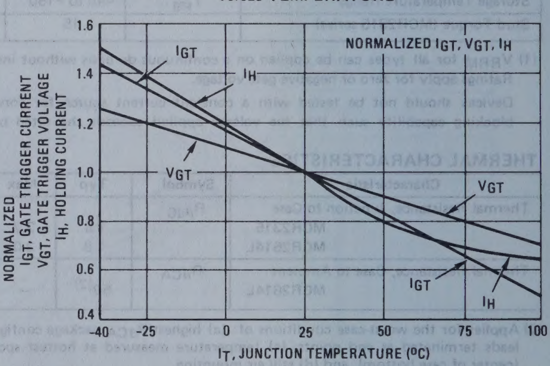


FIGURE 2 – TYPICAL PARAMETER VARIATIONS versus TEMPERATURE



MCR3818-1 thru MCR3818-8 (SILICON)
MCR3918-1 thru MCR3918-8

THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current — I_{TSM} = 240 Amp
- Low Forward "On" Voltage — 1.2 V (Typ) @ I_{TM} = 20 Amp
- Practical Level Triggering and Holding Characteristics — 10 mA (Typ) @ $T_C = 25^oC$
- Rugged Construction in Either Pressfit or Stud Package

THYRISTORS
PNPN

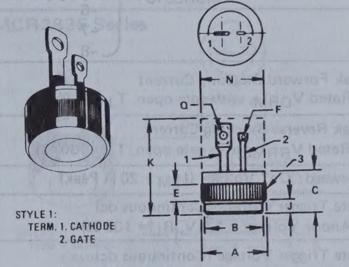
20 AMPERES RMS
25 thru 600 VOLTS

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage	-1	V_{RRM}(1)	25	Volts
MCR3818	-2		50	
MCR3918	-3		100	
	-4		200	
	-5		300	
	-6		400	
	-7		500	
	-8		600	
Non-repetitive Peak Reverse Blocking Voltage ($t \leq 5.0$ ms)	-1	V_{RSM}	35	Volts
MCR3818	-2		75	
MCR3918	-3		150	
	-4		300	
	-5		400	
	-6		500	
	-7		600	
	-8		700	
Forward Current RMS		$I_{T(RMS)}$	20	Amp
Peak Surge Current (one cycle, 60 Hz) (T_J = -40 to +100°C)		I_{TSM}	240	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)		I^2t	235	A^2s
Peak Gate Power		P_{GM}	5.0	Watt
Average Gate Power		$P_{G(AV)}$	0.5	Watt
Peak Forward Gate Current		I_{GM}	2.0	Amp
Peak Gate Voltage				Volts
Forward		V_{GFM}	10	
Reverse		V_{GRM}	10	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (MCR3918 Series)		—	30	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.

MCR3818 Series



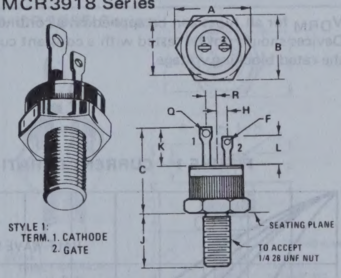
STYLE 1:
TERM. 1. CATHODE
2. GATE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.726	12.827	0.501	0.505
B	11.811	12.065	0.465	0.475
C	8.39	9.65	0.330	0.380
E	2.54	–	0.100	–
F	0.89	1.72	0.035	0.068
J	2.04	2.46	0.080	0.097
K	–	20.32	–	0.800
N	–	12.95	–	0.510
Q	1.66	2.28	0.065	0.090

All JEDEC dimensions and notes apply

CASE 174-02
TO-203AA

MCR3918 Series



STYLE 1:
TERM. 1. CATHODE
2. GATE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.34	15.60	0.604	0.614
B	14.00	14.20	0.551	0.559
C	20.70	24.13	0.815	0.950
F	1.40	1.65	0.055	0.065
H	2.29 REF		0.090 REF	
J	10.67	11.56	0.420	0.455
K	9.78	10.54	0.385	0.415
L	6.99	7.75	0.275	0.305
Q	2.03	2.41	0.080	0.095
R	1.65 REF		0.065 REF	
T	12.70	12.83	0.500	0.505

CASE 175

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C)	V_{DRM}(1)				Volts
MCR3818, MCR3918 -1		25	–	–	
-2		50	–	–	
-3		100	–	–	
-4		200	–	–	
-5		300	–	–	
-6		400	–	–	
-7		500	–	–	
-8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)	I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)	I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 20 A Peak)	V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)	I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω) (Anode Voltage = Rated V_{DRM}, R_L = 100 Ω, T_J = 100°C)	V_{GT} V_{GD}	– 0.2	0.7 –	1.5 –	Volts
Holding Current (Anode Voltage = 7.0 V, gate open)	I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 20 Adc, I_{GT} = 40 mAdc)	t_{on}	–	1.0	–	μs
Turn-Off Time (I_{TM} = 10 A, I_R = 10 A) (I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)	t_{off}	 – –	 15 25	 – –	μs
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	–	50	–	V/μs
Thermal Resistance, Junction to Case MCR3818 MCR3918	θ_{JC}	 – –	 – –	 1.5 1.6	°C/W

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 — CURRENT DERATING

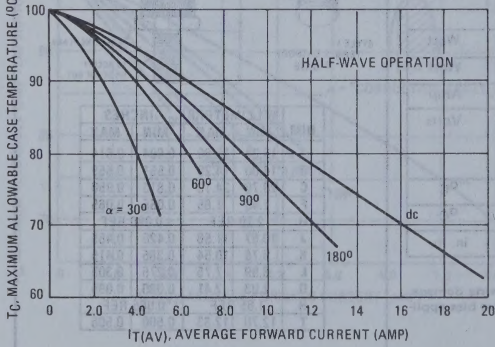
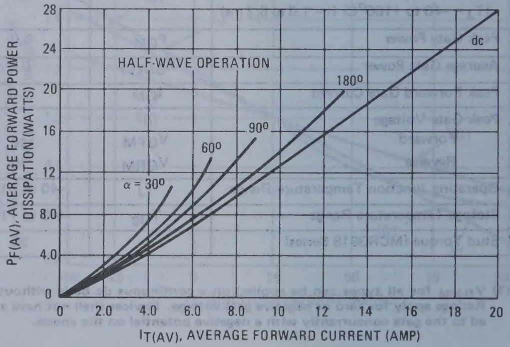


FIGURE 2 — POWER DISSIPATION



MCR3835-1 thru MCR3835-8 (SILICON)
MCR3935-1 thru MCR3935-8

THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current — I_{TSM} = 325 Amp
- Low Forward "On" Voltage — 1.2 V (Typ) @ I_{TM} = 35 Amp
- Practical Level Triggering and Holding Characteristics — 10 mA (Typ) @ T_C = 25°C
- Rugged Construction in Either Pressfit or Stud Package

THYRISTORS
PNPN

35 AMPERES RMS
25 thru 600 VOLTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage	V_{RRM}(1)		Volts
MCR3835 / MCR3935 -1		25	
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
-7		500	
-8		600	
Non-Repetitive Peak Reverse Blocking Voltage ($t \le 5.0$ ms)	V_{RSM}		Volts
MCR3835 / MCR3935 -1		35	
-2		75	
-3		150	
-4		300	
-5		400	
-6		500	
-7		600	
-8		700	
Forward Current RMS	$I_{T(RMS)}$	35	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = -40 to +100°C)	I_{TSM}	325	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)	I^2t	435	A^2s
Peak Gate Power	P_{GFM}	5.0	Watts
Average Gate Power	$P_{GF(AV)}$	0.5	Watt
Peak Forward Gate Current	I_{GFM}	2.0	Amp
Peak Gate Voltage — Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (MCR3935 Series)	—	30	in. lb.

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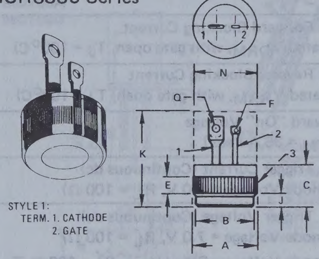
(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.

MCR3835 Series

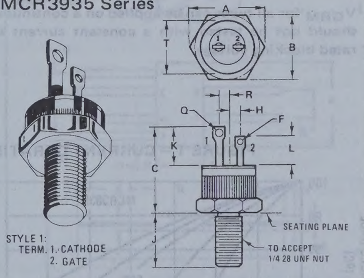


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.726	12.827	0.501	0.505
B	11.811	12.065	0.465	0.475
C	8.39	9.65	0.330	0.380
E	2.54	–	0.100	–
F	0.89	1.72	0.035	0.068
J	2.04	2.46	0.080	0.097
K	–	20.32	–	0.800
N	–	12.95	–	0.510
Q	1.66	2.28	0.065	0.090

All JEDEC dimensions and notes apply

CASE 174-02
TO-203AA

MCR3935 Series



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.34	15.60	0.604	0.614
B	14.00	14.20	0.551	0.559
C	20.70	24.13	0.815	0.950
F	1.40	1.65	0.055	0.065
H	2.29 REF		0.090 REF	
J	10.67	11.56	0.420	0.455
K	9.78	10.54	0.385	0.415
L	6.99	7.75	0.275	0.305
Q	2.03	2.41	0.080	0.095
R	1.65 REF		0.065 REF	
T	12.70	12.83	0.500	0.505

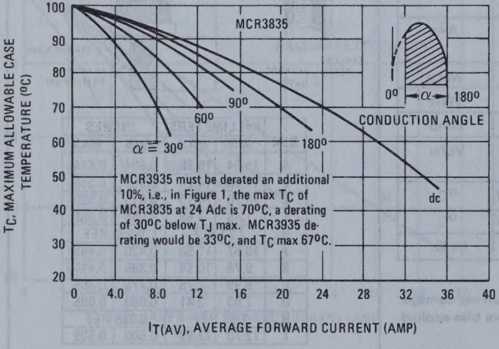
CASE 175

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage ($T_J = 100^oC$)	MCR3835 MCR3935 -1 -2 -3 -4 -5 -6 -7 -8	V_{DRM}(1)	25 50 100 200 300 400 500 600	– – – – – – – –	– – – – – – – –	Volts
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, $T_J = 100^oC$)		I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, $T_J = 100^oC$)		I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 35 A Peak)		V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, $R_L = 100\ \Omega$)		I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, $R_L = 100\ \Omega$) (Anode Voltage = Rated V_{DM}, $R_L = 100\ \Omega$, $T_J = 100^oC$)		V_{GT} V_{GD}	– 0.2	0.7 –	1.5 –	Volts
Holding Current (Anode Voltage = 7.0 V, gate open)		I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 35 Adc, I_{GT} = 40 mAdc)		t_{on}	–	1.0	–	µs
Turn-Off Time (I_{TM} = 10 A, I_R = 10 A) (I_{TM} = 10 A, I_R = 10 A, $T_J = 100^oC$)		t_{off}	– –	15 25	– –	µs
Forward Voltage Application Rate ($T_J = 100^oC$)		dv/dt	–	50	–	V/µs
Thermal Resistance, Junction to Case	MCR3835 MCR3935	θ_{JC}	– –	– –	1.2 1.3	$^oC/W$

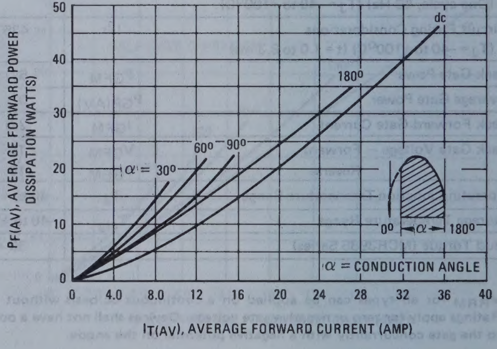
(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING



MCR3935 must be derated an additional 10%, i.e., in Figure 1, the max T_C of MCR3835 at 24 Adc is 70^oC, a derating of 30^oC below T_J max. MCR3935 derating would be 33^oC, and T_C max 67^oC.

FIGURE 2 – TYPICAL POWER DISSIPATION



MD708, F (SILICON)
MD708A, AF
MD708B, BF

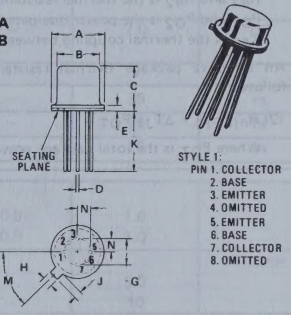
NPN SILICON ANNULAR MULTIPLE TRANSISTORS

. . . designed for use as differential amplifiers, dual high-speed switches, front end detectors and temperature compensation applications.

- Excellent Matching Characteristics @ I_C = 10 mAdc
  h_{FE1}/h_{FE2} = 0.9 (Min) – MD708A,AF
  = 0.8 (Min) – MD708B,BF
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.20 Vdc (Max) @ I_C = 10 mAdc
- DC Current Gain Specified from 500 μAdc to 150 mAdc
- High Current-Gain–Bandwidth Product –
  f_T = 300 MHz (Min) @ I_C = 20 mAdc
- Fast Switching Time –
  t_{on} = 35 ns (Max)
  t_{off} = 75 ns (Max)

NPN SILICON MULTIPLE TRANSISTORS

MD708
MD708A
MD708B

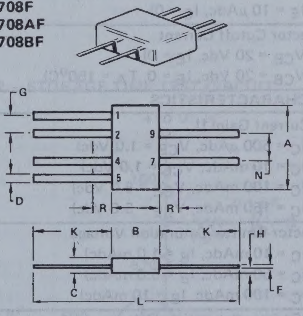


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD708F
MD708AF
MD708BF



STYLE 1:
PIN 1. BASE 5. BASE
2. EMITTER 7. COLLECTOR
4. EMITTER 9. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Die	Both Die Equal Power	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD708,MD708A,MD708B		550	600	
MD708F,MD708AF,MD708BF		350	400	
Derate above 25°C				mW/°C
MD708,MD708A,MD708B		3.13	3.42	
MD708F,MD708AF,MD708BF		2.0	2.28	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD708,MD708A,MD708B		1.4	2.0	
MD708F,MD708AF,MD708BF		0.7	1.4	
Derate above 25°C				mW/°C
MD708,MD708A,MD708B		8.0	11.4	
MD708F,MD708AF,MD708BF		4.0	8.0	

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD708,MD708A,MD708B		319	292	
MD708F,MD708AF,MD708BF		500	438	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD708,MD708A,MD708B		125	87.5	
MD708F,MD708AF,MD708BF		250	125	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD708,MD708A,MD708B		83	40	
MD708F,MD708AF,MD708BF		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$K_{\theta 2}$ is the thermal coupling between die 1 and die 2.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to:

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2} = P_{DT} = 2\,P_D$, equation (3) can be further simplified and by substituting into equation (2) results in:

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted).

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 30$ mAdc, $I_B = 0$)	BV_{CEO}	15	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	40	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
($V_{CB} = 20$ Vdc, $I_E = 0$)		–	15	nAdc
($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = 150^oC$)		–	30	μAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			
($I_C = 500\ \mu$Adc, $V_{CE} = 1.0$ Vdc)		40	–	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		40	200	
($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)		35	–	
($I_C = 150$ mAdc, $V_{CE} = 5.0$ Vdc)		20	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		–	0.20	
($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		–	0.35	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)		–	0.50	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)		0.65	0.85	
($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)		–	0.95	
($I_C = 100$ mAdc, $I_B = 10$ mAdc)		–	1.10	

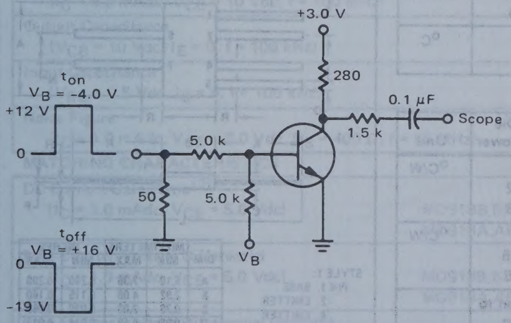
(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)		C_{ob}	–	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 MHz)		C_{ib}	–	7.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)		t_{on}	–	35	ns
Turn-Off Time (Figure 2)		t_{off}	–	75	ns
Storage Time (Figure 2)		t_s	–	25	ns
MATCHING CHARACTERISTICS					
DC Current Gain Ratio(2) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MD708A,AF MD708B,BF	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	–
Base Votlage Differential (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MD708A,AF MD708B,BF	$\lvert V_{BE1}-V_{BE2}\rvert$	– –	5.0 10	mVdc
Base-Emitter Voltage Differential Change (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C to 125°C)	MD708A,AF MD708B,BF	$\frac{\Delta\lvert V_{BE1}/V_{BE2}\rvert}{\Delta T_A}$	– –	10 20	µVdc

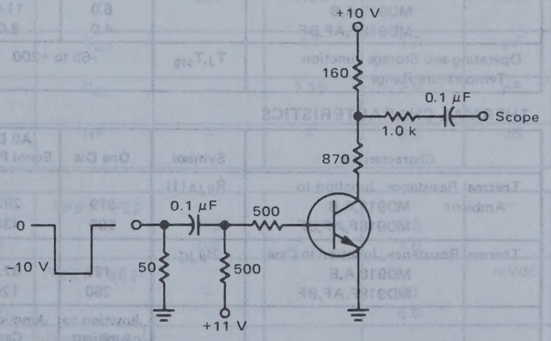
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



+3.0 V
280
t_{on}
V_B = -4.0 V
+12 V
0
5.0 k
1.5 k
0.1 µF
Scope
50
5.0 k
t_{off}
V_B = +16 V
V_B
0
-19 V

FIGURE 2 — STORAGE TIME TEST CIRCUIT



+10 V
160
0.1 µF
Scope
1.0 k
870
0.1 µF
500
0
-10 V
50
500
+11 V

MD918, A, B (SILICON)

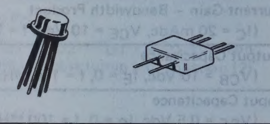
MD918F, AF, BF

MULTIPLE SILICON ANNULAR TRANSISTORS

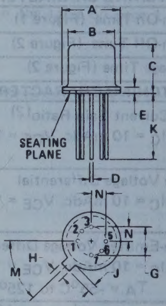
. . . designed for use as differential amplifiers, dual high frequency amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)} = 0.2$ Vdc (Max) @ $I_C = 10$ mAdc
- DC Current Gain – 50 (Min) @ $I_C = 3.0$ mAdc
- High Current-Gain – Bandwidth Product – $f_T = 600$ MHz @ $I_C = 4.0$ mAdc

NPN SILICON MULTIPLE TRANSISTORS



MD918
MD918A
MD918B

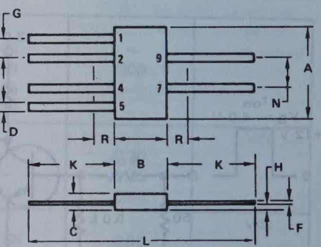


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

CASE 654-07

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

MD918F
MD918AF
MD918BF



STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

CASE 610A-03

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		One Die	All Die	
Total Power Dissipation @ $T_A = 25^oC$ MD918,A,B MD918F,AF,BF Derate Above 25°C MD918,A,B MD918F,AF,BF	P_D	 550 350 3.14 2.0	 600 400 3.42 2.28	 mW mW/°C
Total Power Dissipation @ $T_C = 25^oC$ MD918,A,B MD918F,AF,BF Derate Above 25°C MD918,A,B MD918F,AF,BF	P_D	 1.4 0.7 8.0 4.0	 2.0 1.4 11.4 8.0	 Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient MD918,A,B MD918F,AF,BF	$R_{\theta JA}$(1)	 319 500	 292 438	°C/W
Thermal Resistance, Junction to Case MD918,A,B MD918F,AF,BF	$R_{\theta JC}$	 125 250	 87.5 125	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factors MD918,A,B MD918F,AF,BF		 83 75	 40 0	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$k_{\theta 2}$ is the thermal coupling between die 1 and die 2

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2}$, $P_{DT} = 2P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage[1] (I_C = 3.0 mAdc, I_B = 0)		BV_{CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)		BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 — —	 — —	 10 1.0	 nAdc μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 5.0 Vdc)		h_{FE}	50	165	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 Adc)		$V_{CE(sat)}$	—	0.09	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	0.86	0.9	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	600	1150	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	1.1	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	1.15	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 Ω, f = 60 MHz)		NF	—	—	6.0	dB
MATCHING CHARACTERISTICS						
DC Current-Gain Ratio[2] (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MD918B,BF MD918A,AF	h_{FE1}/h_{FE2}	0.8 0.9	— —	1.0 1.0	—
Base-Emitter Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MD918B,BF MD918A,AF	$\|V_{BE1}-V_{BE2}\|$	— —	— —	10 5.0	mVdc
Base-Emitter Voltage Differential Gradient (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = −55 to +125°C)	MD918B,AF,BF MD918A	$\Delta\|V_{BE1}-V_{BE2}\|/\Delta T_A$	— —	— —	20 10	μV/dc °C

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

FIGURE 1 – DC CURRENT GAIN

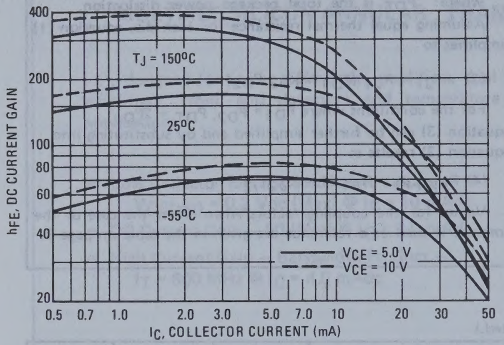


FIGURE 2 – "ON" VOLTAGES

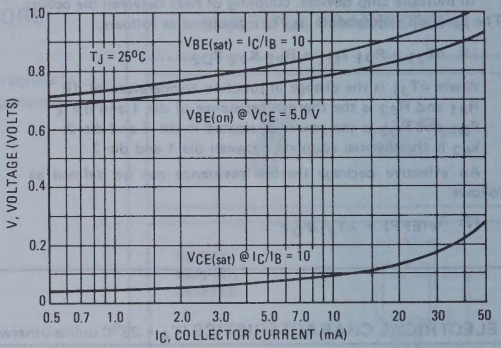


FIGURE 3 – BASE-EMITTER TEMPERATURE COEFFICIENT

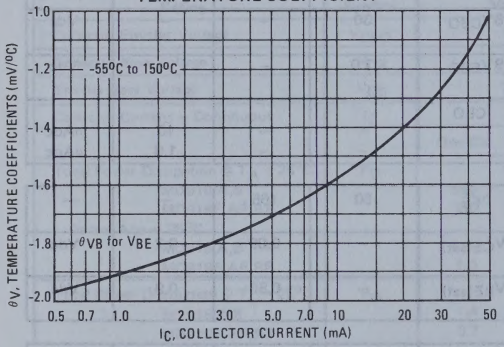


FIGURE 4 – CURRENT-GAIN BANDWIDTH PRODUCT

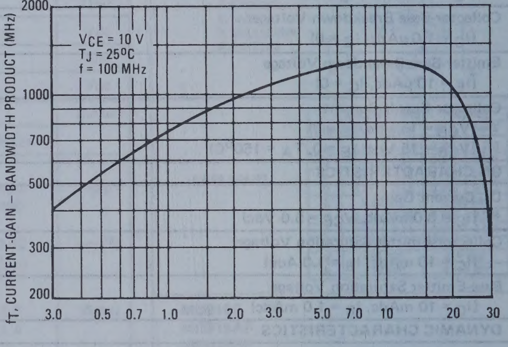
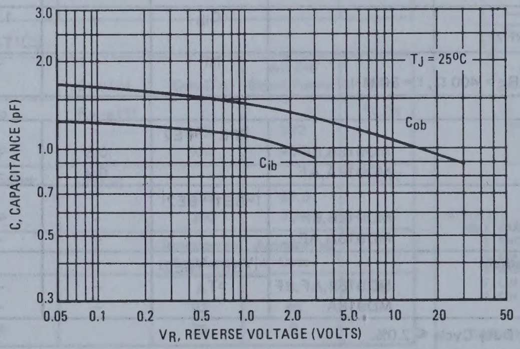


FIGURE 5 – CAPACITANCE



MD982 (SILICON)
MD982F
MQ982

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors, and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 150 mAdc
- DC Current Gain Specified —
  100 μAdc to 150 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 320 MHz (Typ) @ I_C = 50 mAdc

PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

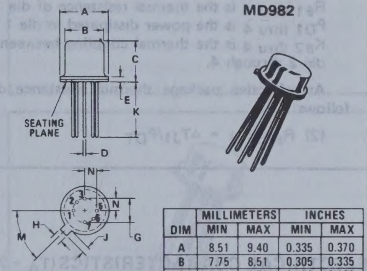
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	50		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD982		600	650	
MD982F		350	400	
MQ982		400	600	
Derate above 25°C				mW/°C
MD982		3.42	3.7	
MD982F		2.0	2.28	
MQ982		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD982		2.1	3.8	
MD982F		1.25	2.5	
MQ982		1.0	4.0	
Derate above 25°C				mW/°C
MD982		12	17.2	
MD982F		7.15	14.3	
MQ982		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD982		292	270	
MD982F		500	438	
MQ982		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD982		83.3	58.3	
MD982F		140	70	
MQ982		175	43.8	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD982		85	40	
MD982F		75	0	
MQ982 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD982

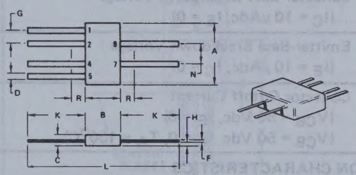


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD982F

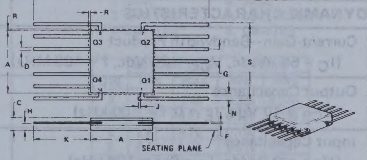


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ982



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4},$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 – –	 – –	 0.020 20	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 20 25 35 40	 50 75 90 60	 – – – –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.25	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.88	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	16	30	pF

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

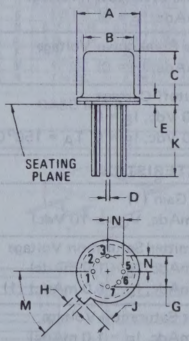
MD984 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTOR

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.18 Vdc (Typ) @ I_C = 10 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 550 MHz (Typ) @ I_C = 20 mAdc

PNP SILICON MULTIPLE TRANSISTOR



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	Both Die Equal Power	
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	575 3.29	625 3.57	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.8 10.3	2.5 14.3	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	$^oC/W$
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$k_{\theta 2}$ is the thermal coupling between die 1 and die 2

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2}$, $P_{DT} = 2P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	– –	25 30	nAdc µAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	75	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (1)	$V_{CE(sat)}$	– –	0.18 0.38	0.3 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.8	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product(1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	550	–	MHz

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle ⩽2.0%.

MD985 (SILICON)
MD985F

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose switches and amplifiers, front end detectors, and temperature compensation amplifiers.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)} = 0.5$ Vdc (Max) @ $I_C = 150$ mAdc
- Fast Switching Times —
  $t_{on} = 25$ ns (Typ) and $t_{off} = 75$ ns (Typ)
- DC Current Gain Specified —
  0.1 mAdc to 150 mAdc
- High Current-Gain—Bandwidth Product —
  $f_T = 320$ MHz (Typ) @ $I_C = 50$ mAdc

NPN/PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

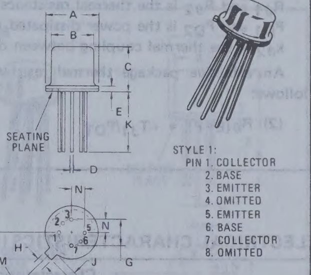
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Die	Both Die Equal Power	
Total Power Dissipation @ $T_A = 25°C$	P_D			mW
MD985		575	625	
MD985F		350	400	
Derate above 25°C				mW/°C
MD985		3.29	3.57	
MD985F		2.0	2.28	
Total Power Dissipation @ $T_C = 25°C$	P_D			Watts
MD985		1.8	2.5	
MD985F		1.0	2.0	
Derate above 25°C				mW/°C
MD985		10.3	14.3	
MD985F		5.71	11.4	

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD985		304	280	
MD985F		500	438	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD985		97	70	
MD985F		175	87.5	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD985		84	44	
MD985F		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD985

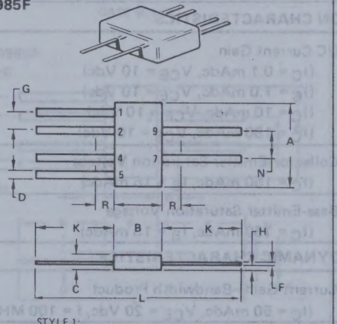


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	.0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	--	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD985F



STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$k_{\theta 2}$ is the thermal coupling between die 1 and die 2

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2}$, $P_{DT} = 2P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = +150^\circ C$)	I_{CBO}	 – –	 – –	 20 20	 nAdc µAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 20 25 35 40	 50 75 90 90	 – – – –	–
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	–	0.3	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	–	1.0	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz) MD985	f_T	200	320	–	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	5.8	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ib}	–	20	–	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc)	t_{on}	–	25	–	ns
Turn-Off Time ($V_{CC} = 30$ Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc)	t_{off}	–	75	–	ns

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle ⩽2.0%.

MD986 (SILICON)
MD986F

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as switches, dual general-purpose amplifiers, front end detectors and in temperature compensation applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 10 mAdc
- DC Current Gain –
  h_{FE} = 25 (Min) @ I_C = 10 mAdc
- High Current-Gain–Bandwidth Product –
  f_T = 200 MHz @ I_C = 20 mAdc
- Fast Switching Time @ I_C = 150 mAdc
  t_{on} = 28 ns (Typ)
  t_{off} = 72 ns (Typ)

NPN/PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

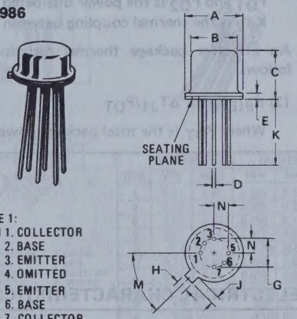
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
		One Die	Both Die Equal Power	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD986		550	600	
MD986F		350	400	
Derate Above 25°C				mW/°C
MD986		3.14	3.42	
MD986F		2.0	2.28	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD986		1.4	2.0	
MD986F		0.7	1.4	
Derate Above 25°C				mW/°C
MD986		8.0	11.4	
MD986F		4.0	8.0	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD986		319	292	
MD986F		500	438	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD986		125	87.5	
MD986F		250	125	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD986		83	40	
MD986F		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD986

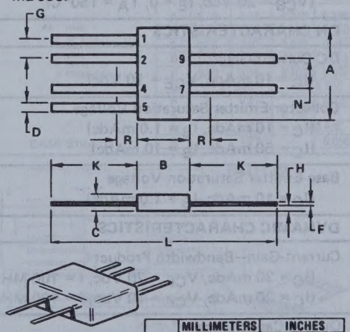


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD986F



STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$K_{\theta 2}$ is the thermal coupling between die 1 and die 2.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to:

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2} = P_{DT} = 2 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in:

(4) $R_{\theta(EFF)} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 – –	 – –	 25 30	 nAdc µAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	–	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 – –	 – –	 0.3 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) MD986F	f_T	200	320	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	–	4.0	pF

(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.

MD1120, MD1120F (SILICON)
MD1121
MD1122
MQ1120

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices
  $\Delta|V_{BE1} - V_{BE2}|$ = 0.8 mVdc (Max) @ -55 to +25°C
  = 1.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 80 mVdc (Typ) @ I_C = 10 mAdc
- DC Current Gain Specified – 10 μAdc to 10 mAdc
- High Current-Gain-Bandwidth Product –
  f_T = 250 MHz @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

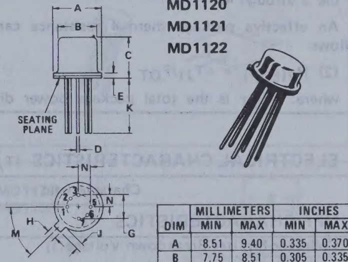
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ T_A = 25°C	P_D			
MD1120,MD1121,MD1122		575	625	mW
MD1120F		350	400	
MQ1120		400	600	
Derate Above 25°C				
MD1120,MD1121,MD1122		3.29	3.57	mW/°C
MD1120F		2.0	2.28	
MQ1120		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			
MD1120,MD1121,MD1122		1.8	2.5	Watts
MD1120F		1.0	2.0	
MQ1120		0.9	3.6	
Derate Above 25°C				
MD1120,MD1121,MD1122		10.3	14.3	mW/°C
MD1120F		5.71	11.4	
MQ1120		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD1120,MD1121,MD1122		304	280	
MD1120F		500	438	
MQ1120		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD1120,MD1121,MD1122		97	70	
MD1120F		175	87.5	
MQ1120		195	48.8	
		Junction to Ambient	Junction to Case	Unit
Coupling Factors				%
MD1120,MD1121,MD1122		84	44	
MD1120F		75	0	
MQ1120 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1)$R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD1120
MD1121
MD1122

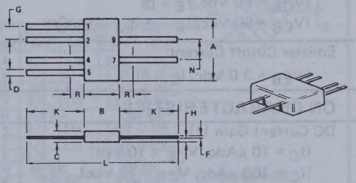


STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

CASE 654-07

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

MD1120F

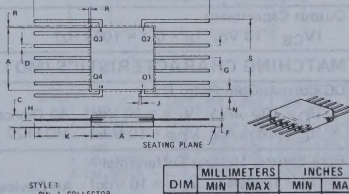


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

CASE 610A-03

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

MQ1120



STYLE 1
PIN 1 COLLECTOR
2 BASE
3 EMITTER
4 NOT CONNECTED
5 EMITTER
6 BASE
7 COLLECTOR
8 COLLECTOR
9 BASE
10 EMITTER
11 NOT CONNECTED
12 EMITTER
13 BASE
14 COLLECTOR

CASE 607-04

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4}$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–		Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	10	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 μAdc, V_{CE} = 10 Vdc)	h_{FE}	20	40	100	–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		30	50	120	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	60	160	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	65	200	
Collector-Emitter Staruation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	80	100	mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	700	850	mVdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product(1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
MATCHING CHARACTERISTICS (MD1120,MD1120F,MD1121 MD1122)					
DC Current Gain Ratio (2) (I_C = 100 μAdc, V_{CE} = 10 Vdc) All Devices	h_{FE1}/h_{FE2}	0.8	–	1.0	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD1122		0.9	–	1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc) All Devices	$\lvert V_{BE1}-V_{BE2}\rvert$	–	–	10	mVdc
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD1122		–	–	5.0	
Base-Emitter Voltage Differential Change Due to Temperature – MD1121, MD1122 (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55 to +25°C)	$\Delta\lvert V_{BE1}-V_{BE2}\rvert$	–	–	0.8	mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)		–	–	1.0	

(1) Pulse test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio

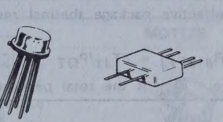
MD1123 (SILICON)
MD1130
MD1130F

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.18 Vdc (Typ) @ I_C = 10 mAdc
- DC Current Gain Specified — 10 μAdc to 10 mAdc — MD1130,F
- High Current-Gain—Bandwidth Product — f_T = 600 MHz @ I_C = 20 mAdc — MD1123

PNP SILICON MULTIPLE TRANSISTORS



MAXIMUM RATINGS

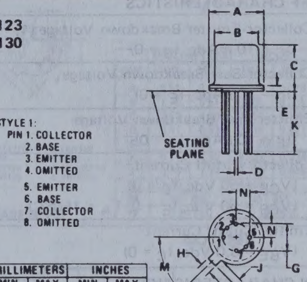
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	All Die	
Total Power Dissipation @ $T_A = 25^\circ C$	P_D			
MD1123, MD1130		575	625	mW
MD1130F		350	400	
Derate Above 25°C				
MD1123, MD1130		3.29	3.57	mW/°C
MD1130F		2.0	2.28	
Total Power Dissipation @ $T_C = 25^\circ C$	P_D			
MD1123, MD1130		1.8	2.5	Watts
MD1130F		1.0	2.0	
Derate Above 25°C				
MD1123, MD1130		10.3	14.3	mW/°C
MD1130F		5.71	11.4	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD1123, MD1130		304	280	
MD1130F		500	438	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD1123, MD1130		97	70	
MD1130F		175	87.5	
		Junction to Ambient	Junction to Case	Unit
Coupling Factors				%
MD1123, MD1130		84	44	
MD1130F		75	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

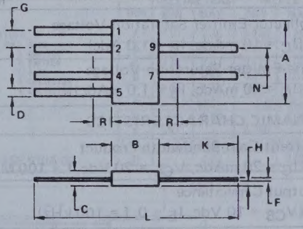
MD1123
MD1130



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07



STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

MD1130F

CASE 610-A03

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
L	10.54	–	0.415	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4},$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})\ /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 50 Vdc, I_E = 0)			–	–	10	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (1)		h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 10 Vdc)	MD1130,F		60	100	–	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1123		30	80	120	
	MD1130,F		100	170	300	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD1130,F		100	180	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD1123		50	75	200	
	MD1130,F		100	150	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 Adc)		$V_{CE(sat)}$	–	0.18	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	–	0.8	0.9	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MD1123	f_T	250	600	–	MHz
	MD1130,F		200	550	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	MD1130,F	C_{ob}	–	3.5	4.0	pF
MATCHING CHARACTERISTICS						
DC Current-Gain Ratio (2)		h_{FE1}/h_{FE2}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1123		0.8	–	1.0	
	MD1130,F		0.9	–	1.0	
Base-Emitter Voltage Differential		$\lvert V_{BE1}/V_{BE2}\rvert$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1123		–	–	10	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD1130,F		–	–	5.0	
Base-Emitter Voltage Differential Change Due to Temperature – MD1121, MD1122 (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)	MD1130,F	$\Delta\lvert V_{BE1}/V_{BE2}\rvert$	–	–	10	mVdc

(1) Pulse test: Pulse Width $\leqslant$300 μs, Duty Cycle $\leqslant$2.0%.

(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD1129 (SILICON)
MD1129F
MQ1129

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — MD1129,F
  $\Delta|V_{BE1} - V_{BE2}| = 0.8$ mVdc (Max) @ −55 to +25°C
  $= 1.0$ mVdc (Max) @ +25°C to +125°C
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)} = 0.09$ Vdc (Typ) @ $I_C = 10$ mAdc — MD1129,MQ1129
- DC Current Gain Specified at Low Collector Currents —
  $h_{FE} = 60$ (Min) @ $I_C = 10\ \mu$Adc
- High Current-Gain-Bandwidth Product —
  $f_T = 250$ MHz (Typ) @ $I_C = 20$ mAdc

NPN SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

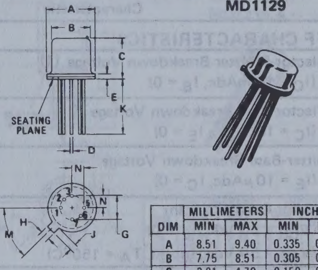
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	**All Die Equal Power**	
Total Power Dissiaption @ $T_A = 25°C$	P_D			mW
MD1129		575	625	
MD1129F		350	400	
MQ1129		400	600	
Derate above 25°C				
MD1129		3.29	3.57	mW/°C
MD1129F		2.0	2.28	
MQ1129		2.28	3.42	
Total Power Dissipation @ $T_C = 25°C$	P_D			
MD1129		1.8	2.5	Watts
MD1129F		1.0	2.0	
MQ1129		0.9	3.6	
Derate above 25°C				
MD1129		10.3	14.3	mW/°C
MD1129F		5.71	11.4	
MQ1129		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)			°C/W
MD1129		304	280	
MD1129F		500	438	
MQ1129		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD1129		97	70	
MD1129F		175	87.5	
MQ1129		195	48.8	
		Junction to Ambient	**Junction to Case**	**Unit**
Coupling Factors				%
MD1129		84	44	
MD1129F		75	0	
MQ1129 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD1129

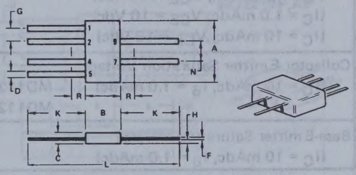


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD1129F

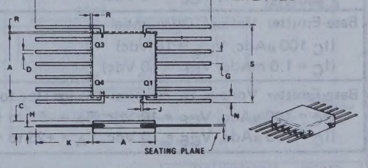


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ1129



STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})\ /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	– –	10 10	nAdc μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 μAdc, V_{CE} = 10 Vdc) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60 100 100 100	– – 120 140	– 300 – –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) MD1129, MQ1129 MD1129F	$V_{CE(sat)}$	– –	0.09 –	0.1 0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (1) (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	250		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
MATCHING CHARACTERISTICS (MD1129, MD1129F)					
DC Current Gain Ratio (2) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	h_{FE1}/h_{FE2}	0.9 0.9	– –	1.0 1.0	–
Base-Emitter Voltage Differential (I_C 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	– –	– –	5.0 5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55 to +25°C) (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = +25 to +125°C)	$\Delta\lvert V_{BE1}-V_{BE2}\rvert$	– –	– –	0.8 1.0	mVdc

(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD1130
MD1130F

For Specifications, See MD1123 Data.

MD2218, MD2218A (SILICON)
MD2218F, MD2218AF
MD2219, MD2219A
MD2219F, MD2219AF
MQ2218, A, MQ2219, A

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Fast Switching – MD2218A,AF, MD2219A,AF
  t_d = 15 μs (Max) t_r = 30 μs (Max)
  t_s = 250 μs (Max) t_f = 60 μs (Max)
- Low Collector-Emitter Saturation Voltage – MD2218AF, MD2219AF
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 150 mAdc
- DC Current Gain Specified – MD2218,A, MD2219,A
  0.1 mAdc to 300 mAdc
- High Current-Gain-Bandwidth Product
  f_T = 250 MHz (Typ) @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

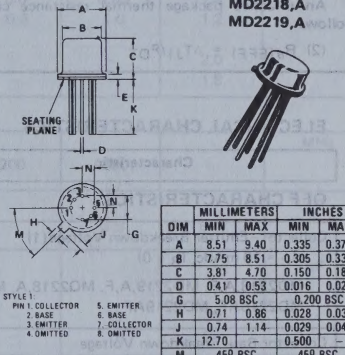
Rating	Symbol	MD2218,A,F MD2219,A,F MQ2218,A MQ2219,A	MD2218AF MD2219AF	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current – Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25°C$	P_D			
MD2218,A,MD2219,A		575	625	mW
MD2218F,AF, MD2219F,AF		350	400	
MQ2218,A, MQ2219,A		400	600	
Derate Above 25°C				
MD2218,A,MD2219,A		3.29	3.57	mW/°C
MD2218F,AF,MD2219F,AF		2.0	2.28	
MQ2218,A,MQ2219,A		2.28	3.42	
Total Power Dissipation @ $T_C = 25°C$	P_D			
MD2218,A,MD2219,A		1.8	2.5	Watts
MD2218F,AF,MD2219F,AF		1.0	2.0	
MQ2218,A,MQ2219,A		0.9	3.6	
Derate Above 25°C				
MD2218,A,MD2219,A		10.3	14.3	mW/°C
MD2218F,AF,MD2219F,AF		5.71	11.4	
MQ2218,A,MQ2219,A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD2218,A,MD2219,A		304	280	
MD2218,F,AF,MD2219,F,AF		500	438	
MQ2218,A,MQ2219,A		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD2218,A,MD2219,A		97	70	
MD2218F,AF,MD2219F,AF		175	87.5	
MQ2218,A,MQ2219,A		195	48.8	
		Junction to Ambient	Junction to Case	
Coupling Factors				
MD2218,A,MD2219,A		84	44	%
MD2218F,AF,MD2219F,AF		75	0	
MQ2218,A,MQ2219,A (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD2218,A
MD2219,A

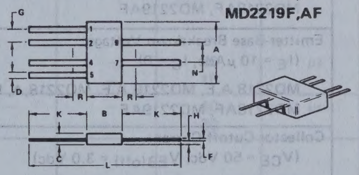


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD2218F,AF
MD2219F,AF

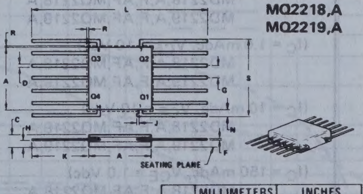


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ2218,A
MQ2219,A



STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}				Vdc
MD2218,A,F, MD2219,A,F, MQ2218,A, MQ2219,A		30	–	–	
MD2218AF, MD2219AF		40	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}				Vdc
MD2218,A,F,MD2219,A,F,MQ2218,A,MD2219,A		60	–	–	
MD2218AF, MD2219AF		75	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}				Vdc
MD2218,A,F, MD2219,A.F. MQ2218,A, MQ2219,A		5.0	–	–	
MD2218AF, MD2219AF		6.0	–	–	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEV}				nAdc
MD2218,F,MD2219,F,MQ2218,A		20	–	–	
MD2218A,AF,MD2219A,AF,MQ2219,A		15	–	–	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{BL}	30	–	–	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		20	50	–	
MD2219,A,F,AF,MQ2219,A		35	45	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		25	55	–	
MD2219,A,F,AF,MQ2219,A		50	55	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		35	65	–	
MD2219,A,F,AF,MQ2219,A		75	85	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)					
MD2218,A,F,AF,MQ2218,A		20	65	–	
MD2219,A,F,AF,MQ2219,A		50	65	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,F,AF,MQ2218,A		40	30	120	
MD2219,A,F,AF,MQ2219,A		100	120	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)					
MD2218,A,MQ2218,A		25	75	–	
MD2219,A,MQ2219,A		30	75	–	

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS (continued) (1)					
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)					
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	0.2	0.4	
MD2218AF, MD2219AF		–	–	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)					
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	0.35	1.2	
MD2218AF,MD2219AF		–	–	0.9	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)					
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		0.6	0.95	1.3	
MD2218AF,MD2219AF		0.6	1.0	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)					
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	–	2.0	
MD2218AF,MD2219AF		–	–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz	f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}				pF
MD2218,A,F,MD2219,A,F,MQ2218,A,MQ2219,A		–	15	30	
MD2218AF,MD2219AF		–	18	25	
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = 15 mAdc) (Figure 11) MD2218,F,MD2219,F	t_d	–	–	20	μs
MD2218A,AF,MD2219A,AF		–	–	15	
Rise Time MD2218,F,MD2219,F	t_r	–	–	40	μs
MD2218A,AF,MD2219A,AF		–	–	30	
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 12) MD2218,F,MD2219,F	t_s	–	–	280	μs
MD2218A,AF,MD2219A,AF		–	–	250	
Fall Time MD2218,F,MD2219,F	t_f	–	–	70	μs
MD2218A,AF,MD2219A,AF		–	–	60	

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

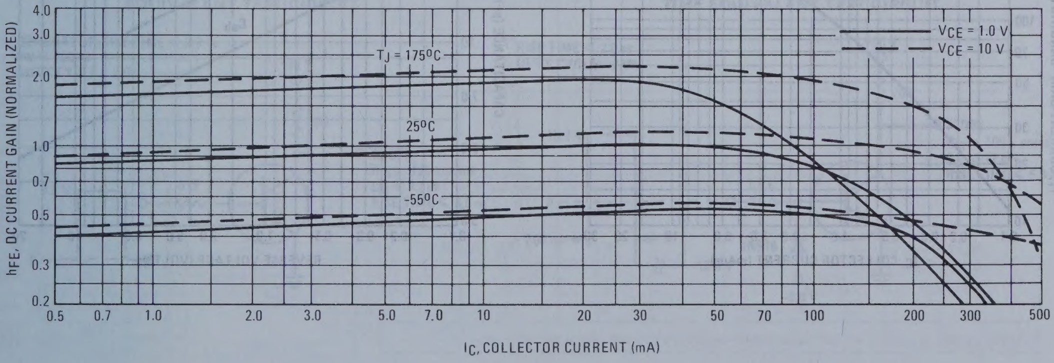


FIGURE 2 – "ON" VOLTAGES

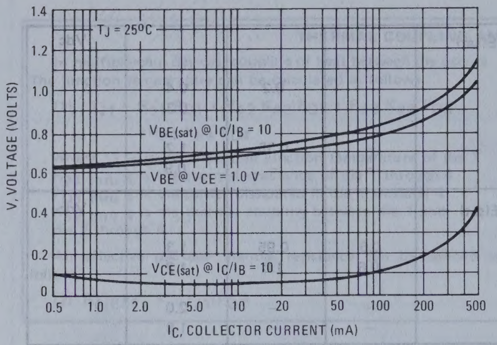
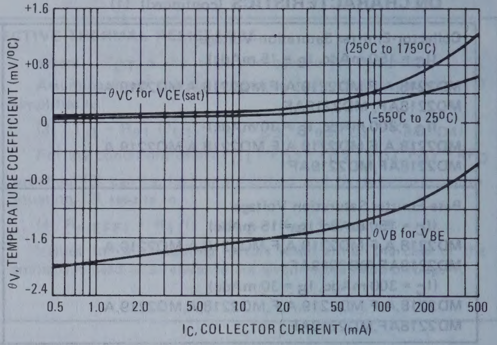


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE
(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 4 – FREQUENCY EFFECTS

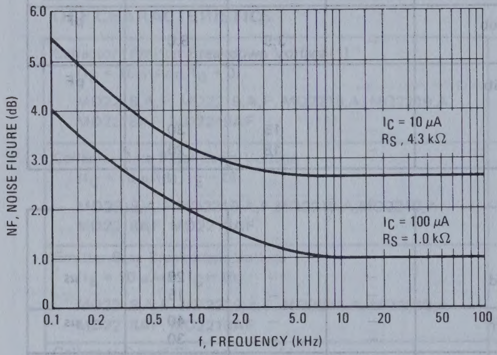


FIGURE 5 – SOURCE RESISTANCE EFFECTS

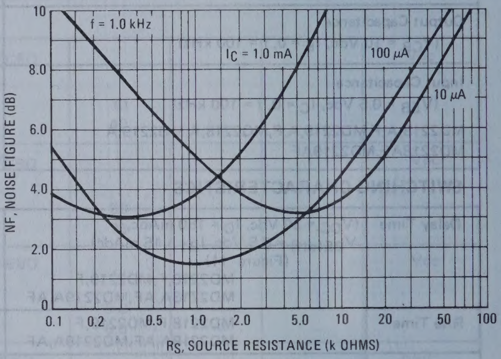


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

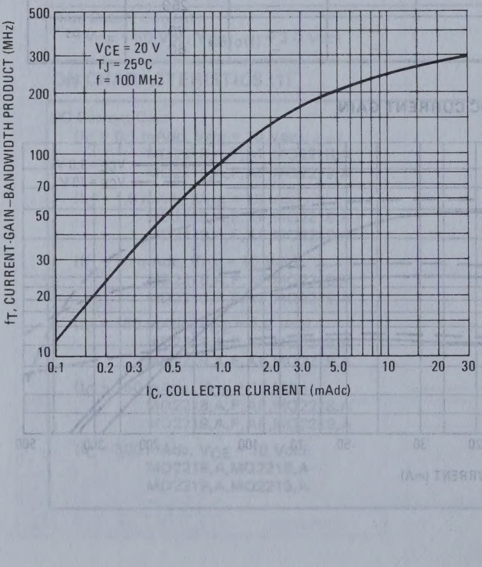
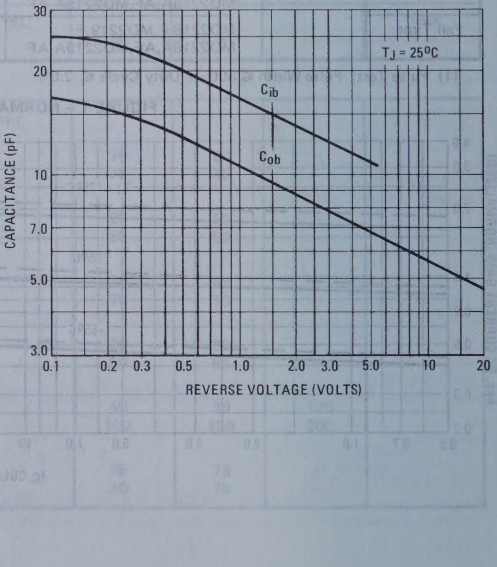


FIGURE 7 – CAPACITANCES



SWITCHING TIME CHARACTERISTICS

FIGURE 8 – TURN-ON TIME

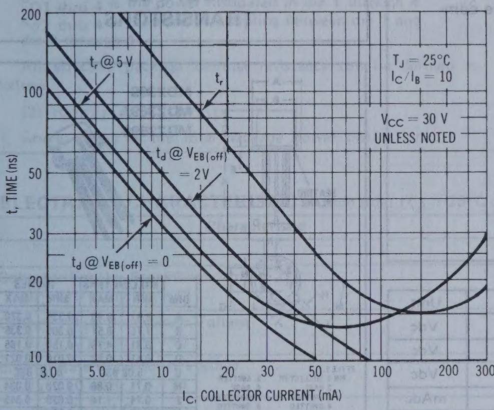


FIGURE 9 – CHARGE DATA

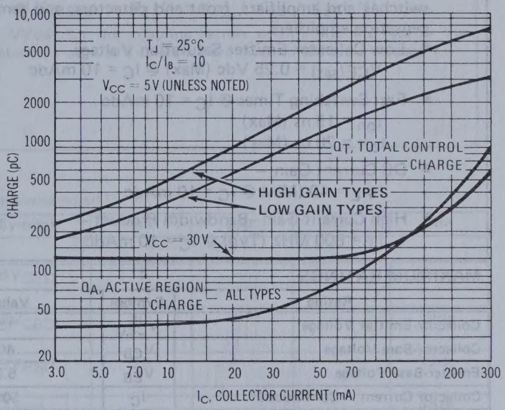


FIGURE 10 – TURN-OFF BEHAVIOR

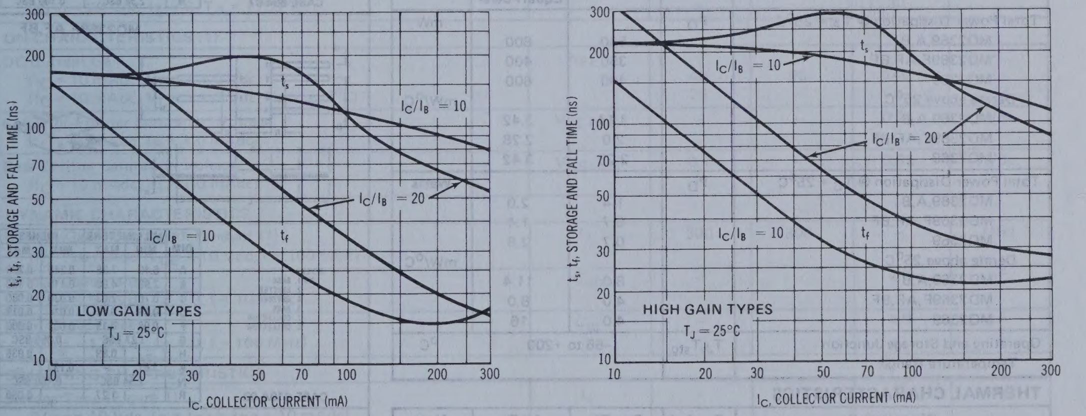


FIGURE 11 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

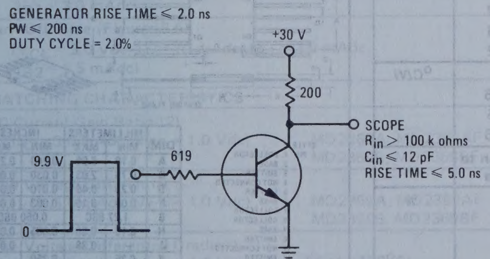
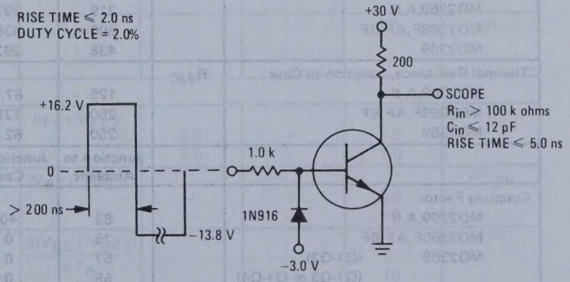

GENERATOR RISE TIME ≤ 2.0 ns
PW ≤ 200 ns
DUTY CYCLE = 2.0%
+30 V
200
SCOPE
R_in > 100 k ohms
C_in ≤ 12 pF
RISE TIME ≤ 5.0 ns
619
9.9 V
0

FIGURE 12 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT


RISE TIME ≤ 2.0 ns
DUTY CYCLE = 2.0%
+30 V
200
SCOPE
R_in > 100 k ohms
C_in ≤ 12 pF
RISE TIME ≤ 5.0 ns
+16.2 V
0
1.0 k
> 200 ns
1N916
–13.8 V
–3.0 V

MD2369, A, B (SILICON)
MD2369F, AF, BF
MQ2369

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose switches and amplifiers, front end detectors, and temperature compensation amplifiers.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = 0.25$ Vdc (Max) @ $I_C = 10$ mAdc
- Fast Switching Times @ $I_C = 10$ mAdc
  $t_{on} = 15$ ns (Max)
  $t_{off} = 20$ ns (Max)
- DC Current Gain — $h_{FE} = 40$ (Min) @ $I_C = 10$ mAdc
- High Current-Gain—Bandwidth Product — $f_T = 800$ MHz (Typ) @ $I_C = 10$ mAdc

NPN SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

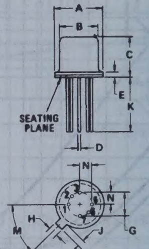
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25°C$	P_D			mW
MD2369,A,B		550	600	
MD2369F,AF,BF		350	400	
MQ2369		400	600	
Derate above 25°C				mW/°C
MD2369,A,B		3.14	3.42	
MD2369F,AF,BF		2.0	2.28	
MQ2369		2.28	3.42	
Total Power Dissipation @ $T_C = 25°C$	P_D			Watts
MD2369,A,B		1.4	2.0	
MD2369F,AF,BF		0.7	1.4	
MQ2369		0.7	2.8	
Derate above 25°C				mW/°C
MD2369,A,B		8.0	11.4	
MD2369F,AF,BF		4.0	8.0	
MQ2369		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD2369,A,B		319	292	
MD2369F,AF,BF		500	438	
MQ2369		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD2369,A,B		125	87.5	
MD2369F,AF,BF		250	125	
MQ2369		250	62.6	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD2369,A,B		83	40	
MD2369F,AF,BF		75	0	
MQ2369 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD2369
MD2369A
MD2369B

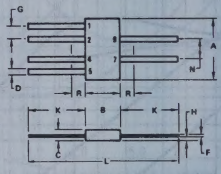


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD2369F,AF,BF

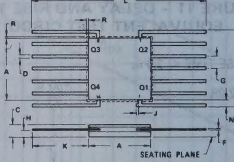


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ2369



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$) ($V_{CB} = 20$ Vdc, $I_E = 0$, $T_A = +150^\circ C$)	I_{CBO}	 – –	 – –	 0.03 30	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55^\circ C$)	h_{FE}	 40 20	 95 –	 140 –	–
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	0.7	–	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	500	800	–	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	–	4.0	pF
Input Capacitance ($V_{BE} = 1.0$ Vdc, $I_C = 0$, f = 100 MHz)	C_{ib}	–	–	4.0	pF
SWITCHING CHARACTERISTICS					
Storage Time (Figure 1) ($V_{CC} = 10$ Vdc, $I_C = I_{B1} = I_{B2} = 10$ mAdc)	t_s	–	–	13	ns
Turn-On Time (Figures 2,4) ($V_{CC} = 3.0$ Vdc, $V_{BE(off)} = 1.5$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{on}	–	–	15	ns
Turn-Off Time (Figures 3,5) ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc, $I_{B2} = 1.5$ mAdc)	t_{off}	–	–	20	ns
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (2) ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc) MD2369A, MD2369AF MD2369B, MD2369BF	h_{FE1}/h_{FE2}	 0.9 0.8	 – –	 1.0 1.0	–
Base Voltage Differential ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc) MD2369A, MD2369AF MD2369B, MD2369BF	$\lvert V_{BE1}-V_{BE2} \rvert$	 – –	 – –	 5.0 10	mVdc
Base Voltage Differential Gradient ($I_C = 3.0$ mAdc, $V_{CE} = 1.0$ Vdc, $T_A = -55$ to $+125^\circ C$) MD2369A, MD2369AF MD2369B, MD2369BF	$\frac{\Delta \lvert V_{BE1}-V_{BE2} \rvert}{\Delta T_A}$	 – –	 – –	 10 20	$\mu V/^\circ C$

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

FIGURE 1 – STORAGE TIME TEST CIRCUIT

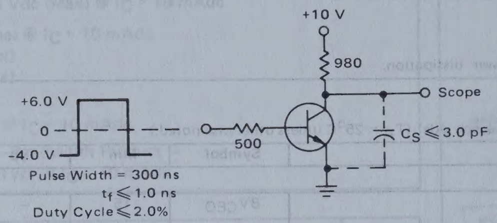

+10 V
980
Scope
+6.0 V
0
-4.0 V
500
$C_S \leqslant 3.0$ pF
Pulse Width = 300 ns
$t_f \leqslant 1.0$ ns
Duty Cycle ≤ 2.0%

FIGURE 2 – TURN-ON TIME

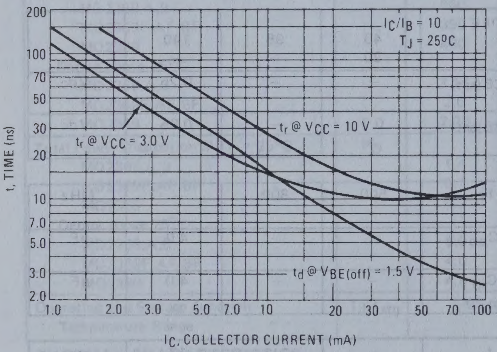


FIGURE 3 – TURN-OFF TIME

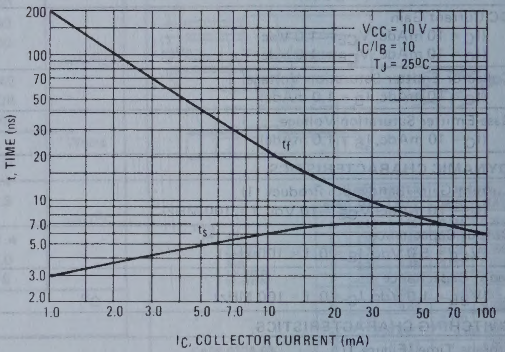


FIGURE 4 – TURN-ON TEST CIRCUIT

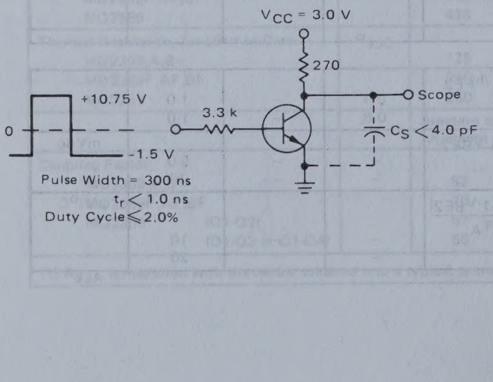

V_{CC} = 3.0 V
270
Scope
+10.75 V
0
-1.5 V
3.3 k
$C_S < 4.0$ pF
Pulse Width = 300 ns
$t_r \leqslant 1.0$ ns
Duty Cycle ≤ 2.0%

FIGURE 5 – TURN-OFF TEST CIRCUIT

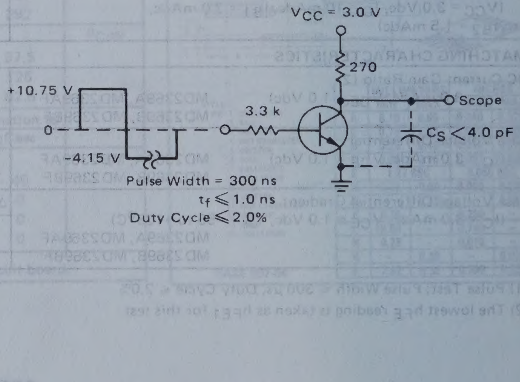

V_{CC} = 3.0 V
270
Scope
+10.75 V
0
-4.15 V
3.3 k
$C_S < 4.0$ pF
Pulse Width = 300 ns
$t_f \leqslant 1.0$ ns
Duty Cycle ≤ 2.0%

FIGURE 6 – CAPACITANCE

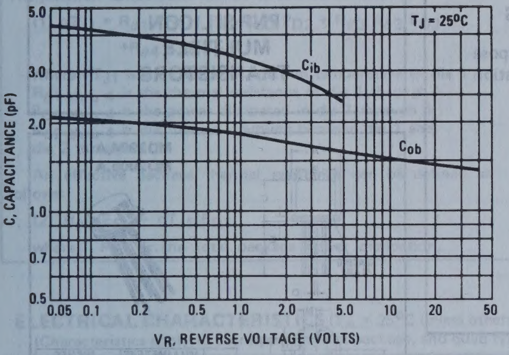


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

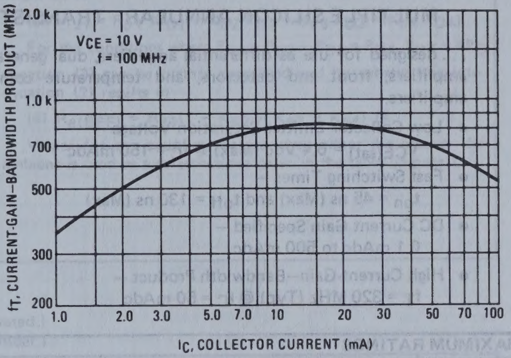


FIGURE 8 – DC CURRENT GAIN

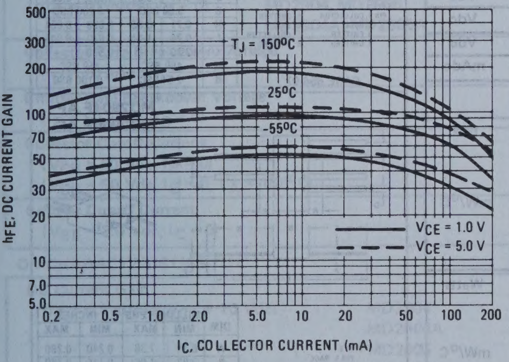


FIGURE 9 – "ON" VOLTAGES

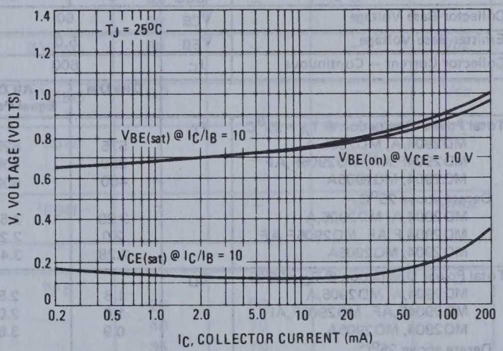


FIGURE 10 – COLLECTOR SATURATION REGION

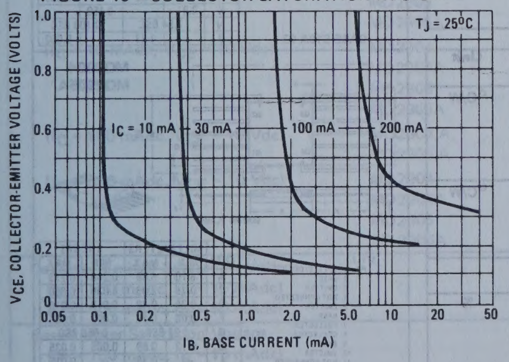
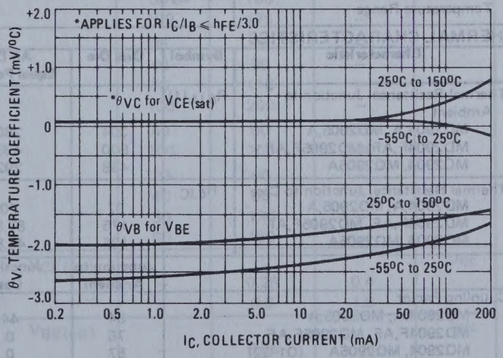


FIGURE 11 – TEMPERATURE COEFFICIENTS



MD2904, MD2904A (SILICON)
MD2904F, MD2904AF
MD2905, MD2905A
MD2905F, MD2905AF
MQ2904, MQ2905A

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors, and temperature compensation amplifiers.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- Fast Switching Times — t_{on} = 45 ns (Max) and t_{off} = 130 ns (Max)
- DC Current Gain Specified — 0.1 mAdc to 500 mAdc
- High Current-Gain—Bandwidth Product — f_T = 320 MHz (Typ) @ I_C = 50 mAdc

PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

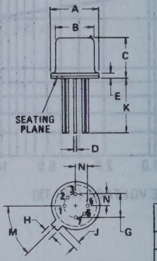
Rating	Symbol	MD2904,F MD2905,F MQ2904	MD2904A,AF MD2905A,AF MQ2905A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	**All Die Equal Power**	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD2904,A, MD2905,A		575	625	
MD2904F,AF, MD2905F,AF		350	400	
MQ2904, MQ2905A		400	600	
Derate above 25°C				mW/°C
MD2904,A, MD2905,A		3.29	3.57	
MD2904,F,AF, MD2905F,AF		2.0	2.28	
MQ2904, MQ2905A		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD2904,A, MD2905,A		1.8	2.5	
MD2904F,AF, MD2905F,AF		1.0	2.0	
MQ2904, MQ2905A		0.9	3.6	
Derate above 25°C				mW/°C
MD2904,A, MD2905,A		10.3	14.3	
MD2904F,AF, MD2905F,AF		5.71	11.4	
MQ2904, MQ2905A		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

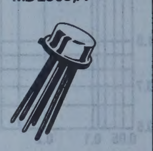
THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD2904,A, MD2905,A		304	280	
MD2904F,AF, MD2905F,AF		500	438	
MQ2904, MQ2905A		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD2904,A, MD2905,A		97	70	
MD2904F,AF, MD2905F,AF		175	87.5	
MQ2904, MQ2905A		195	48.8	
		Junction to Ambient	**Junction to Case**	
Coupling Factor				%
MD2904,A, MD2905,A		84	44	
MD2904F,AF, MD2905F,AF		75	0	
MQ2904, MQ2905A (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD2904,A
MD2905,A



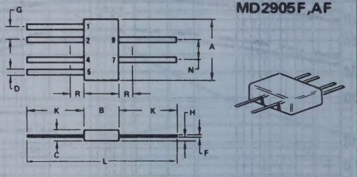


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD2904F,AF
MD2905F,AF

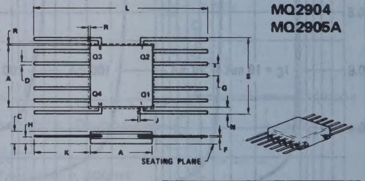


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ2904
MQ2905A



STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

MD2904, MD2904A, MD2904F, MD2904AF (continued)
MD2905, MD2905A, MD2905F, MD2905AF
MQ2904
MQ2905A

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)
(Characteristics apply to corresponding flat package, and quad type number.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	MD2904, MD2905		40	–	–	
	MD2904A, MD2905A		60	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)			–	–	0.020	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			–	–	30	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	30	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2904		20	50	–	
	MD2904A		40	70	–	
	MD2905		35	70	–	
	MD2905A		75	150	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2904		25	75	–	
	MD2904A		40	75	–	
	MD2905		50	100	–	
	MD2905A		100	175	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2904		35	90	–	
	MD2904A		40	90	–	
	MD2905		75	110	–	
	MD2905A		100	200	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2904,A,		40	90	120	
	MD2905,A		100	200	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MD2904		20	60	–	
	MD2904A		40	80	–	
	MD2905		30	130	–	
	MD2905A		50	150	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.25	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.5	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.88	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.0	2.6	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

MD2904, MD2904A, MD2904F, MD2904AF (continued)
MD2905, MD2905A, MD2905F, MD2905AF
MQ2904
MQ2905A

ELECTRICAL CHARACTERISTICS (continued)

DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	16	30	pF

SWITCHING CHARACTERISTICS

Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 12)	t_{on}	—	—	45	ns
Delay Time		t_d	—	—	12	ns
Rise Time		t_r	—	—	35	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 13)	t_{off}	—	—	130	ns
Storage Time		t_s	—	—	100	ns
Fall Time		t_f	—	—	40	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DC CURRENT GAIN

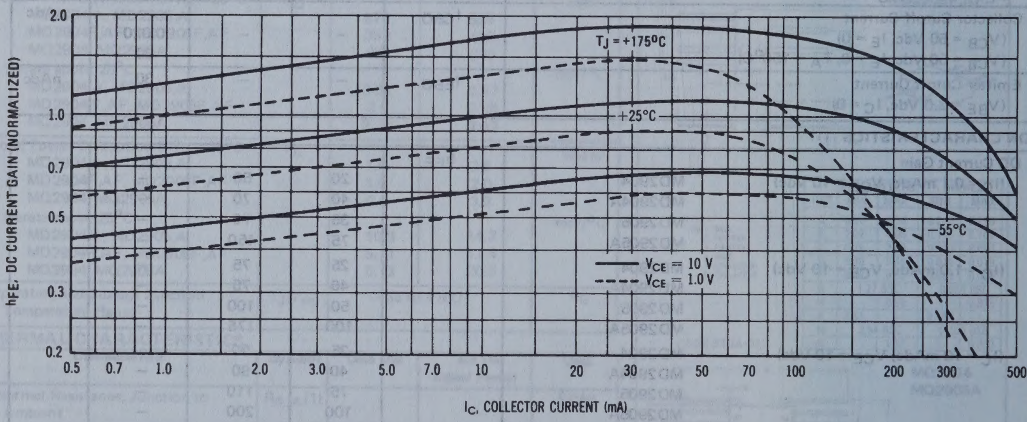


FIGURE 2 – "ON" VOLTAGES

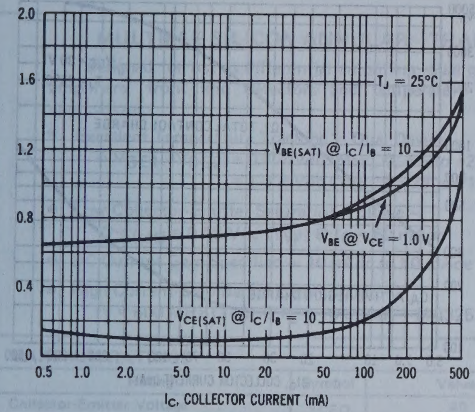
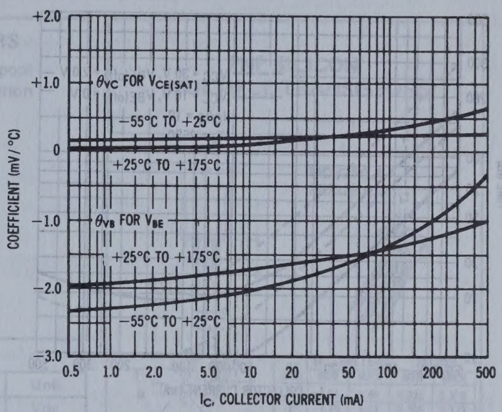


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 4 – FREQUENCY EFFECTS

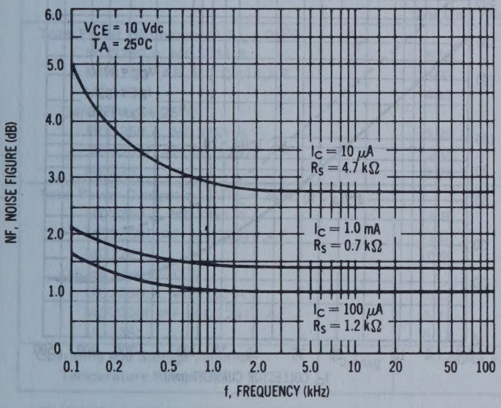


FIGURE 5 – SOURCE RESISTANCE EFFECTS

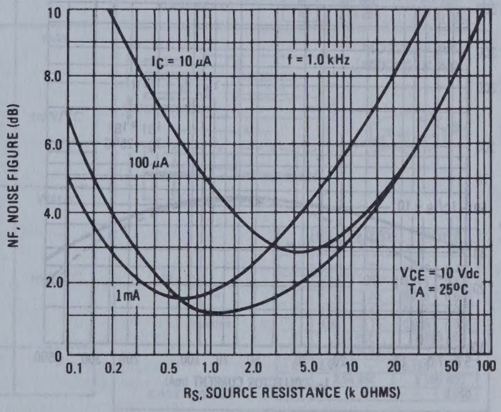


FIGURE 6 – CURRENT-GAIN BANDWIDTH PRODUCT

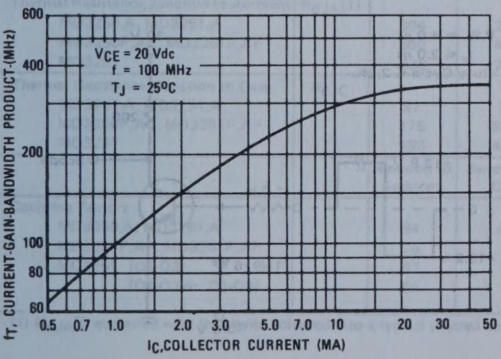


FIGURE 7 – CAPACITANCE

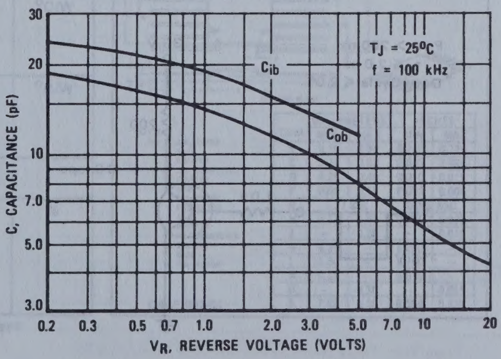


FIGURE 8 – TURN ON TIME

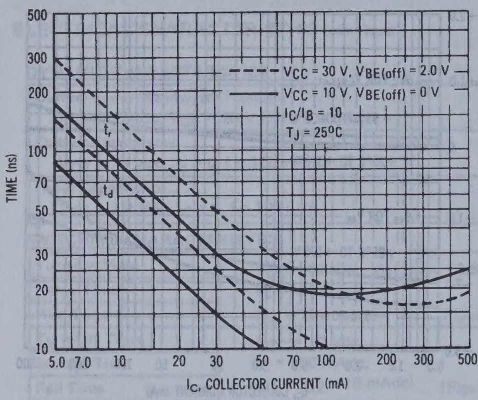


FIGURE 9 – CHARGE DATA

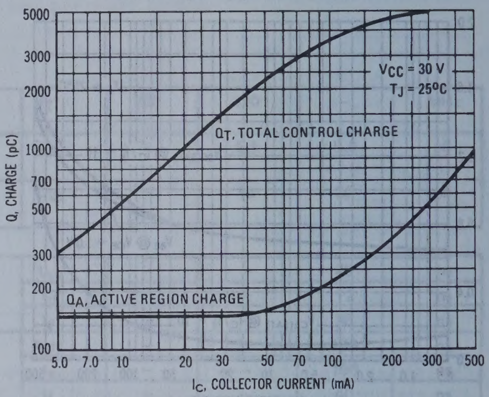


FIGURE 10 – STORAGE TIME

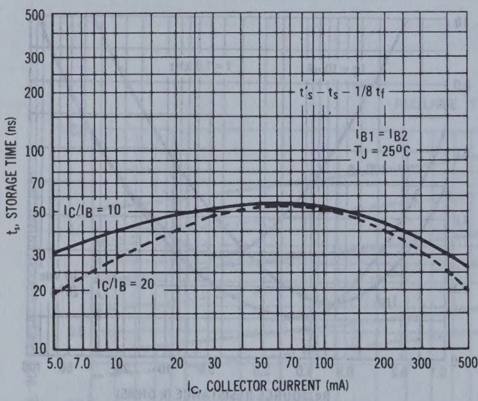


FIGURE 11 – FALL TIME

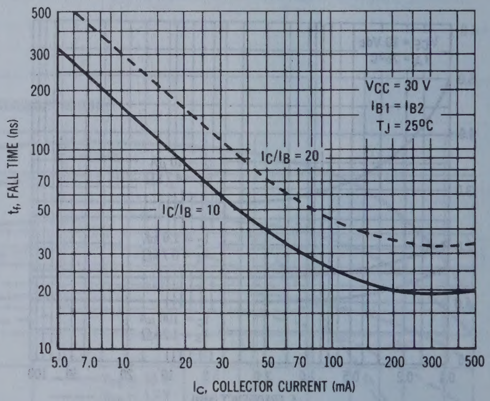


FIGURE 12 – DELAY AND RISE TIME TEST CIRCUIT

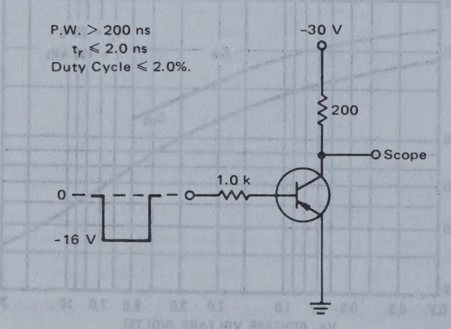
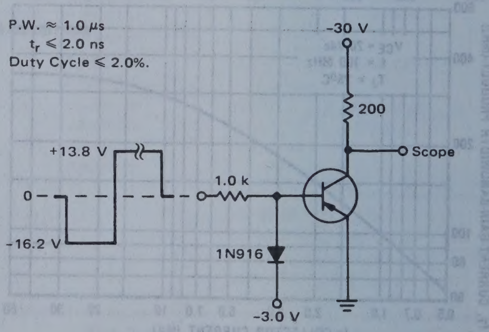

P.W. > 200 ns
tr ≤ 2.0 ns
Duty Cycle ≤ 2.0%.
-30 V
200
Scope
1.0 k
0
-16 V

FIGURE 13 – STORAGE AND FALL TIME TEST CIRCUIT


P.W. ≈ 1.0 μs
tr ≤ 2.0 ns
Duty Cycle ≤ 2.0%.
-30 V
200
Scope
+13.8 V
1.0 k
0
-16.2 V
1N916
-3.0 V

MD3250, A, F, AF (SILICON)
MD3251, A, F, AF
MQ3251

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices
  $\Delta|V_{BE1} - V_{BE2}| = 0.8$ mVdc (Max) @ -55 to +25°C
  $= 1.0$ mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)} = 0.18$ Vdc (Typ) @ $I_C = 50$ mAdc
- DC Current Gain Specified – 10 μAdc to 50 mAdc
- High Current-Gain-Bandwidth Product –
  $f_T = 600$ MHz (Typ) @ $I_C = 10$ mAdc – MQ3251

PNP SILICON MULTIPLE TRANSISTORS

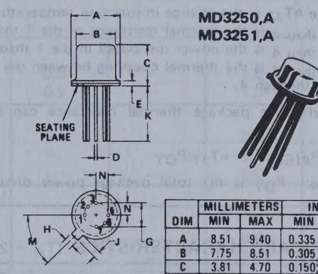
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25°C$	P_D			mW
MD3250,A, MD3251,A		575	625	
MD3250F,AF, MD3251F,AF		350	400	
MQ3251		400	600	
Derate Above 25°C				mW/°C
MD3250,A, MD3251,A		3.29	3.57	
MD3250F,AF, MD3251F,AF		2.0	2.28	
MQ3251		2.28	3.42	
Total Power Dissipation @ $T_C = 25°C$	P_D			Watts
MD3250,A, MD3251,A		1.8	2.5	
MD3250F,AF, MD3251F,AF		1.0	2.0	
MQ3251		0.9	3.6	
Derate Above 25°C				mW/°C
MD3250,A, MD3251,A		10.3	14.3	
MD3250F,AF, MD3251F,AF		5.71	11.4	
MQ3251		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD3250,A, MD3251,A		304	280	
MD3250F,AF, MD3251F,AF		500	438	
MQ3251		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD3251,A, MD3251,A		97	70	
MD3250F,AF, MD3251F,AF		175	87.5	
MQ3251		195	48.8	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD3250,A, MD3251,A		84	44	
MD3250F,AF, MD3251F,AF		75	0	
MQ3251 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

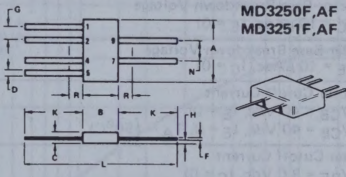
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	--	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

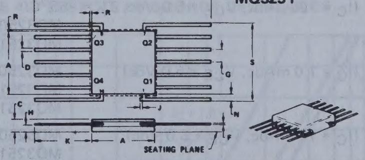
CASE 654-07



STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)		BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	 – –	 – –	 10 10	 nAdc µAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				
(I_C = 10 µAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		25	75	–	
	MD3251,A,F,AF		50	100	–	
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	82	150	
	MD3251,A,F,AF		80	170	300	
	MQ3251		80	170	–	
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	MD3250,A,F,AF		25	35	–	
	MD3251,A,F,AF		50	75	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	87	150	
	MD3251,A,F,AF		100	180	300	
	MQ3251		100	180	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		50	92	–	
	MD3251,A,F,AF		100	190	–	
	MQ3251		100	190	300	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	MD3250,A,F,AF		15	50	–	
	MD3251,A,F,AF		30	90	–	
	MQ3251		30	90	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	 – –	 0.11 0.18	 0.25 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	 0.6 –	 0.78 0.88	 0.9 1.2	Vdc

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz MD3250,A,F,AF	f_T	200	600	–	MHz
MD3251,A,F,AF		250	600	–	
MQ3251		300	600	–	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	2.5	6.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	6.0	8.0	pF

MATCHING CHARACTERISTICS (MD3250A,AF, MD3251A,AF only)

Characteristic	Symbol	Min	Typ	Max	Unit
DC Current Gain Ratio (2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}	0.9	–	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		0.9	–	1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	$\lvert V_{BE1}/V_{BE2}\rvert$	–	–	3.0	mVdc
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		–	–	5.0	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		–	–	5.0	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C)	$\Delta\lvert V_{BE1}/V_{BE2}\rvert$	–	–	0.8	mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)		–	–	1.0	

(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio

FIGURE 1 – CAPACITANCE

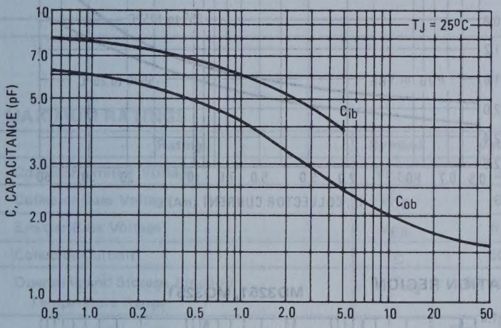
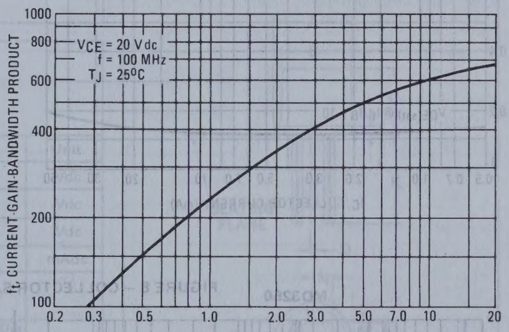


FIGURE 2 – CURRENT-GAIN BANDWIDTH PRODUCT



NOISE FIGURE VARIATIONS

(V_{CE} = 6.0 V, T_A = 25°C)

FIGURE 3 – EFFECTS OF FREQUENCY

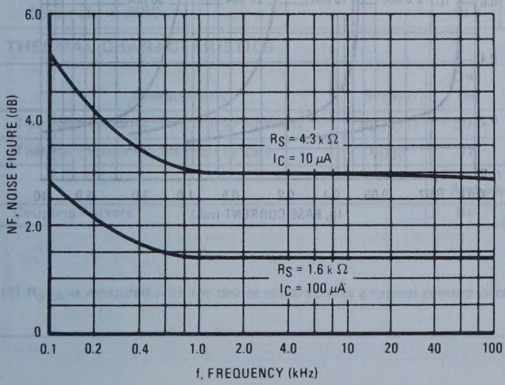


FIGURE 4 – EFFECTS OF SOURCE RESISTANCE

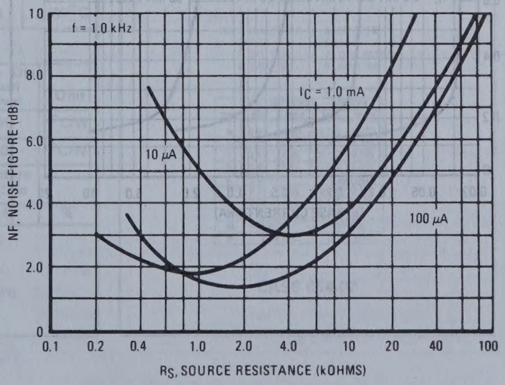


FIGURE 5 – DC CURRENT GAIN

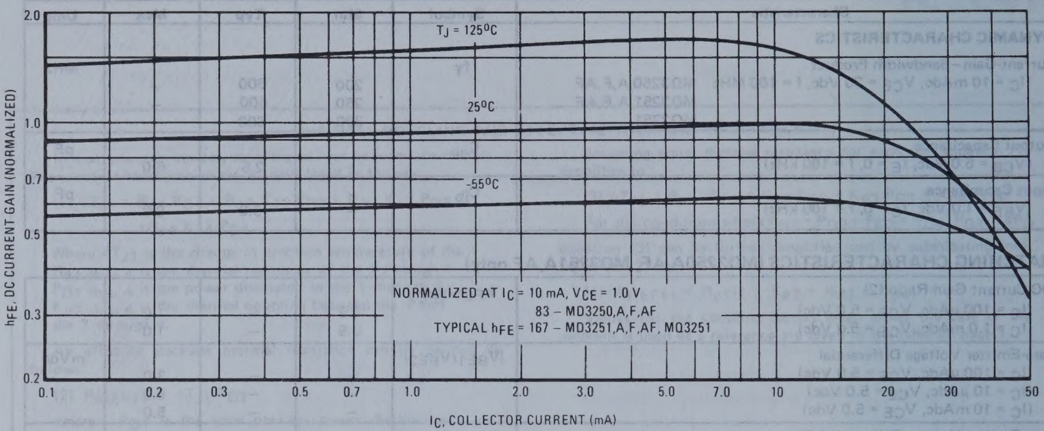


FIGURE 6 – "ON" VOLTAGE

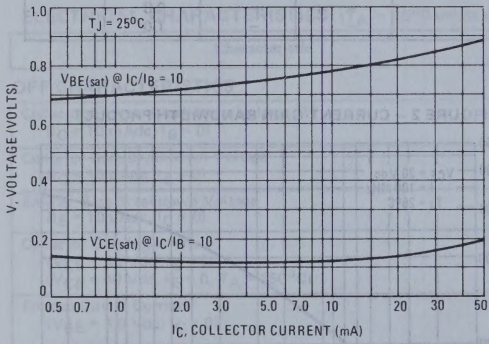


FIGURE 7 – TEMPERATURE COEFFICIENTS

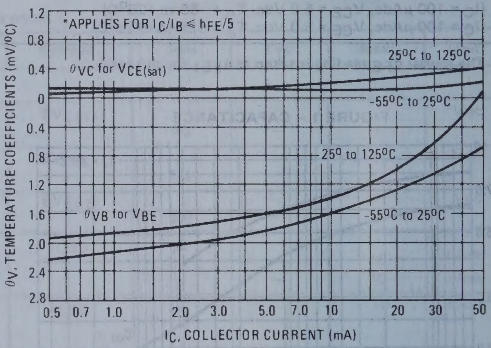
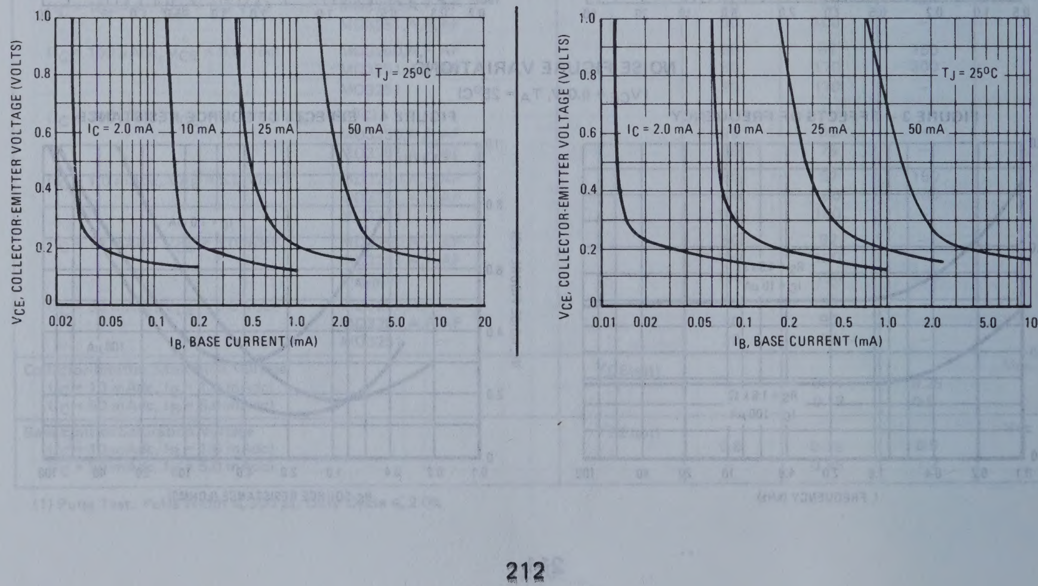


FIGURE 8 – COLLECTOR SATURATION REGION


MD3250

MD3251, MQ3251

MD3409 (SILICON)
MD3410

NPN SILICON ANNULAR MULTIPLE TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – MD3410 –
  $\Delta|V_{BE1}-V_{BE2}| = 0.8$ mVdc (Max) @ $T_A = -55$ to $+25^{\circ}C$
  $= 1.0$ mVdc (Max) @ $T_A = +25$ to $+125^{\circ}C$
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)} = 0.15$ Vdc (Max) @ $I_C = 10$ mAdc
- Low DC Current Gain –
  $h_{FE} = 20\text{-}100$ @ $I_C = 10\ \mu$Adc – MD3410
- High Current-Gain–Bandwidth Product –
  $f_T = 250$ MHz (Typ) @ $I_C = 20$ mAdc

NPN SILICON MULTIPLE TRANSISTORS

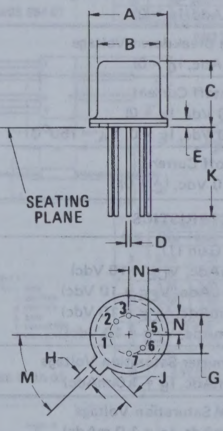
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector-Current	I_C	500		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^{\circ}C$
		One Die	Both Die Equal Power	
Total Power Dissipation @ $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	575 3.29	625 3.57	mW mW/$^{\circ}C$
Total Power Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	1.8 10.3	2.5 14.3	Watts mW/$^{\circ}C$

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	$^{\circ}C/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	$^{\circ}C/W$
		Junction to Ambient	Junction to Case	
Coupling Factors		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1}\, P_{D1} + R_{\theta 2}\, K_{\theta 2}\, P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$K_{\theta 2}$ is the thermal coupling between die 1 and die 2.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to:

(3) $\Delta T_{J1} = R_{\theta 1}\,(P_{D1} + K_{\theta 2}\, P_{D2})$

For the conditions where $P_{D1} = P_{D2} = P_{DT} = 2\,P_D$, equation (3) can be further simplified and by substituting into equation (2) results in:

(4) $R_{\theta(EFF)} = R_{\theta 1}\,(P_{D1} + K_{\theta 2}\, P_{D2})$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 50 Vdc, I_E = 0)			–	–	10	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (1)		h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 10 Vdc)	MD3410		20	40	100	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	Both Devices		30	50	120	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	Both Devices		40	60	160	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	Both Devices		50	65	200	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.09	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	–	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	3.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	15	25	pF
MATCHING CHARACTERISTICS						
Base-Emitter Voltage Differential Change Due to Temperature		$\Delta\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc,	MD3409		–	–	1.6	
T_A = -55°C to +25°C)	MD3410		–	–	0.8	
(I_C = 100 μAdc, V_{CE} = 10 Vdc,	MD3409		–	–	2.0	
T_A = +25°C to +125°C)	MD3410		–	–	1.0	

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%

MD3467 (SILICON)
MD3467F
MQ3467

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, and temperature compensation applications.

- Collector-Emitter Breakdown Voltage – BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.52 Vdc (Typ) @ I_C = 500 mAdc
- DC Current-Gain Specified – h_{FE} = 20 (Min) @ I_C = 500 mAdc
- Fast Switching Times @ I_C = 500 mAdc – t_{on} = 40 ns (Max) t_{off} = 110 ns (Max)

PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

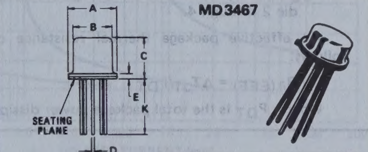
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	1.5		Adc
		One Die	All Die Equal Power	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD3467		600	650	
MD3467F		350	400	
MQ3467		400	600	
Derate above 25°C				mW/°C
MD3467		3.42	3.7	
MD3467F		2.0	2.28	
MQ3467		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD3467		2.1	3.0	
MD3467F		1.25	2.5	
MQ3467		1.0	4.0	
Derate above 25°C				mW/°C
MD3467		12	17.2	
MD3467F		7.15	14.3	
MQ3467		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200		°C

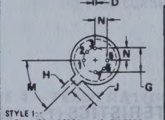
THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD3467		292	270	
MD3467F		500	438	
MQ3467		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD3467		83.3	58.3	
MD3467F		140	70	
MQ3467		175	43.8	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD3467		85	40	
MD3467F		75	0	
MQ3467 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD3467



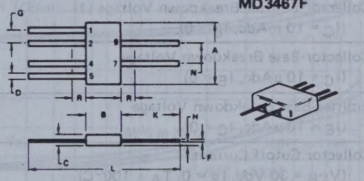


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

CASE 654-07

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

MD3467F

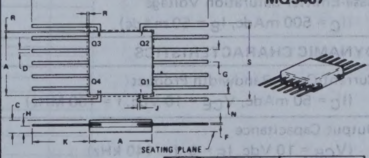


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

CASE 610A-03

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

MQ3467



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

CASE 607-04

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.32	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	–	0.95	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	220		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	8.5	20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	22	80	pF
SWITCHING CHARACTERISTICS					
Delay Time — (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	–	7.0	10	ns
Rise Time	t_r	–	17	30	ns
Storage Time — (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s	–	58	80	ns
Fall Time	t_f	–	14	30	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – DC CURRENT GAIN

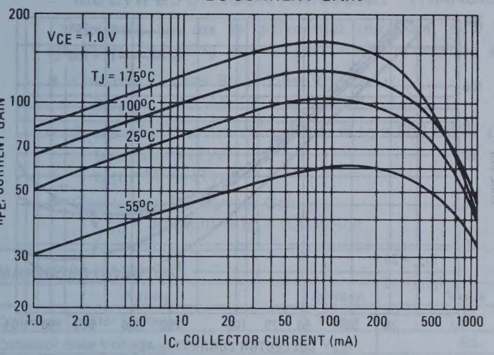


FIGURE 2 – COLLECTOR SATURATION REGION

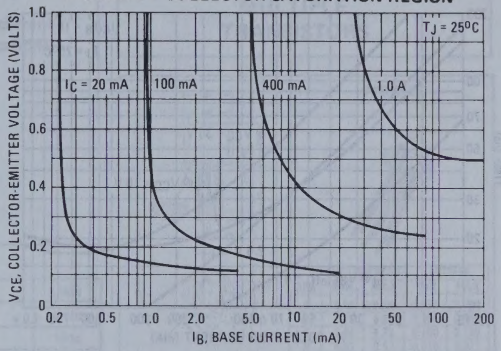


FIGURE 3 – "ON" VOLTAGE

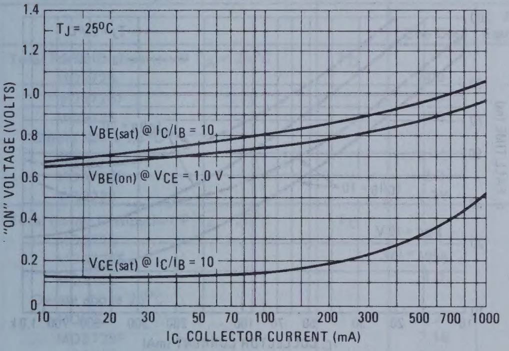


FIGURE 4 – TEMPERATURE COEFFICIENTS

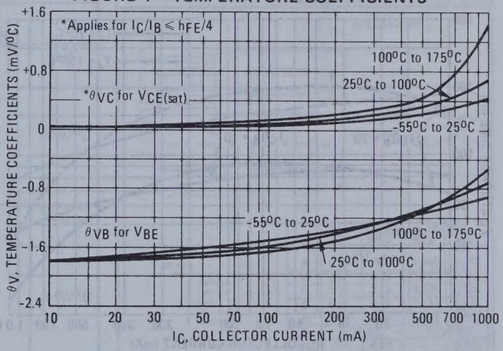


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

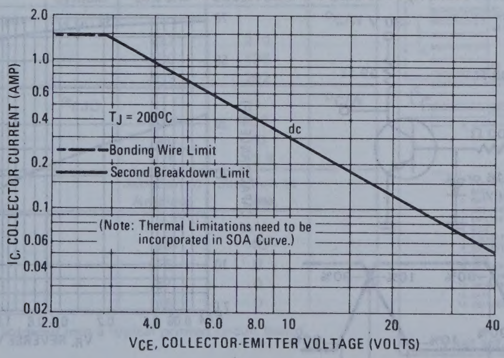


FIGURE 6 – TURN-ON TIME

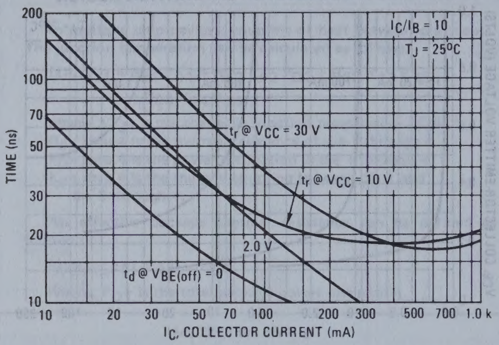


FIGURE 7 – RISE AND FALL TIME

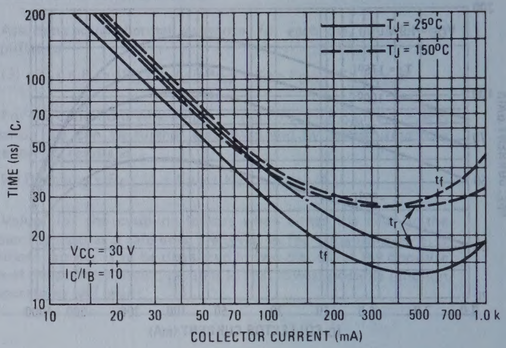


FIGURE 8 – STORAGE TIME

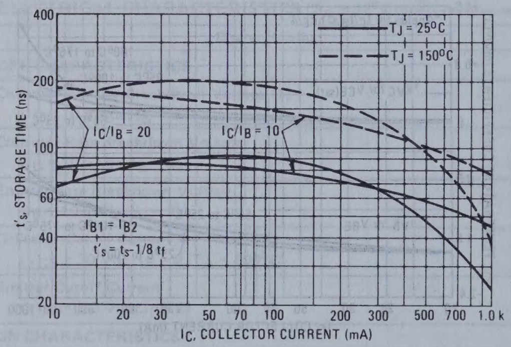


FIGURE 9 – FALL TIME

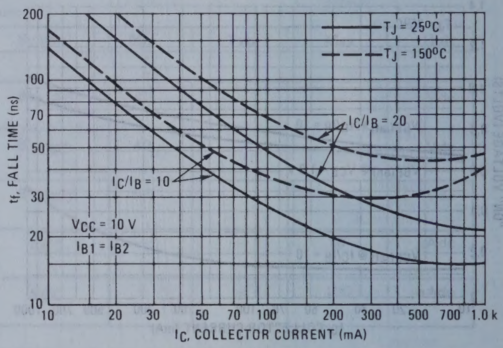


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

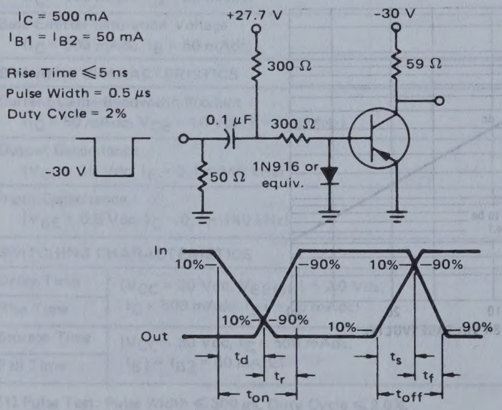
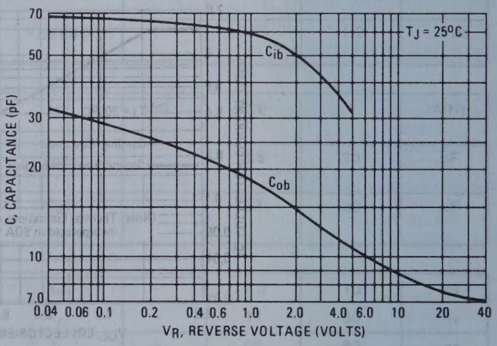

IC = 500 mA
IB1 = IB2 = 50 mA
Rise Time ≤ 5 ns
Pulse Width = 0.5 µs
Duty Cycle = 2%
-30 V
+27.7 V
-30 V
300 Ω
59 Ω
0.1 µF
300 Ω
50 Ω
1N916 or equiv.
In
10%
90%
10%
90%
Out
10%
90%
10%
90%
td
tr
ton
ts
tf
toff

FIGURE 11 – CAPACITANCE



MD3725 (SILICON)
MD3725F
MQ3725

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual high-current amplifiers, switching and temperature compensation applications.

- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Guaranteed Fast Switching Times @ I_C = 500 mAdc
  t_{on} = 20 ns (Typ)
  t_{off} = 50 ns (Typ)
- Guaranteed DC Current Gain –
  h_{FE} = 30 (Min) @ I_C = 500 mAdc

NPN SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

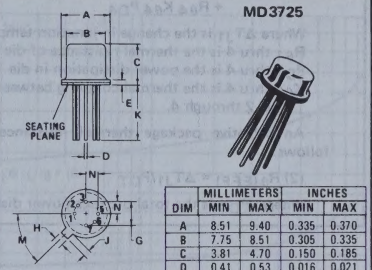
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	65		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25°C$	P_D			mW
MD3725		600	650	
MD3725F		350	400	
MQ3725		400	600	
Derate above 25°C				mW/°C
MD3725		3.42	3.7	
MD3725F		2.0	2.28	
MQ3725		2.28	3.42	
Total Power Dissipation @ $T_A = 25°C$	P_D			Watts
MD3725		2.1	3.0	
MD3725F		1.25	2.5	
MQ3725		1.0	4.0	
Derate above 25°C				mW/°C
MD3725		12	17.2	
MD3725F		7.15	14.3	
MQ3725		5.71	22.8	

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD3725		292	270	
MD3725F		500	438	
MQ3725		433	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD3725		83.3	58.3	
MD3725F		140	70	
MQ3725		175	43.8	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD3725		85	40	
MD3725F		75	0	
MQ3725 (Q1-Q2)		57	0	
(Q1-Q3, Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD3725

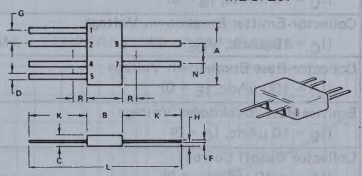


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD3725F

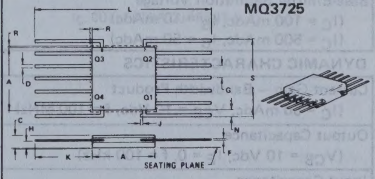


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ3725



STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A/T_C = 25^oC$ unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 µAdc, V_{BE} = 0) MD3725F	BV_{CES}	65	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	BV_{CBO}	65	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	 – –	 0.12 –	 1.7 120	 µAdc µAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 50 30	 – –	 150 –	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	 – –	 0.19 0.30	 0.26 0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	 – 0.80	 – –	 0.86 1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	–	65	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figures 7 and 8) (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = 3.8 Vdc)	t_{on}	–	20	45	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	50	75	ns

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle ⩽2.0%.

TYPICAL DC CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

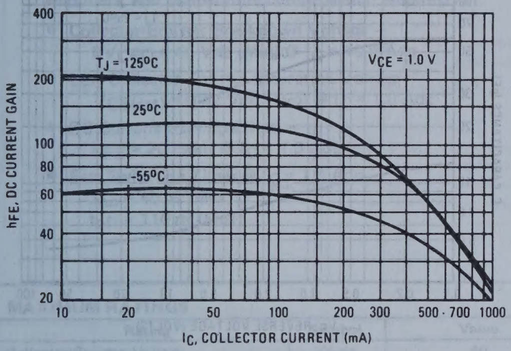


FIGURE 2 – "ON" VOLTAGES

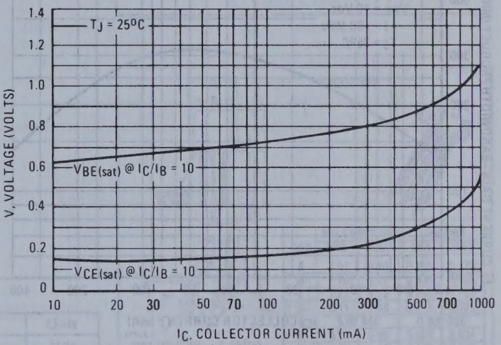


FIGURE 3 – COLLECTOR SATURATION REGION

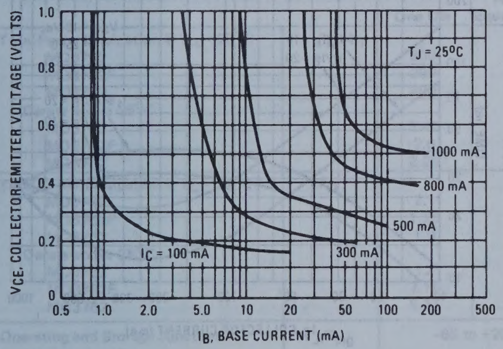
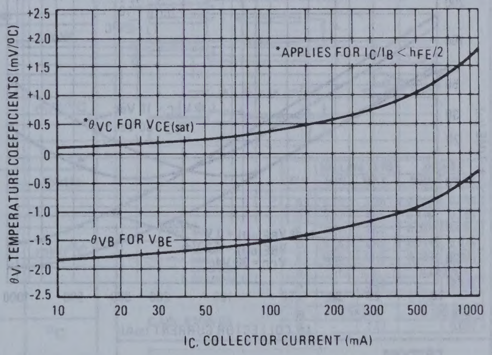


FIGURE 4 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

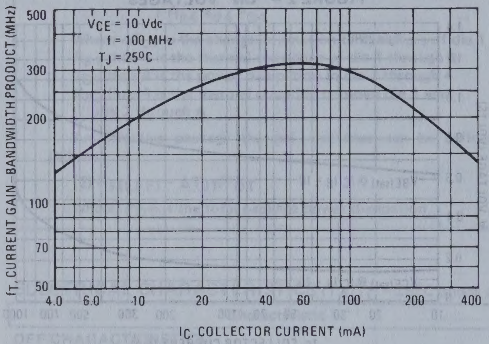


FIGURE 6 – CAPACITANCE

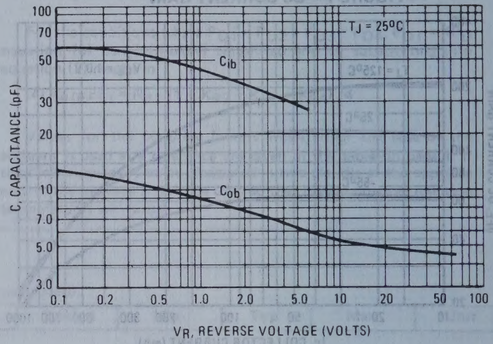


FIGURE 7 – TURN-ON TIME

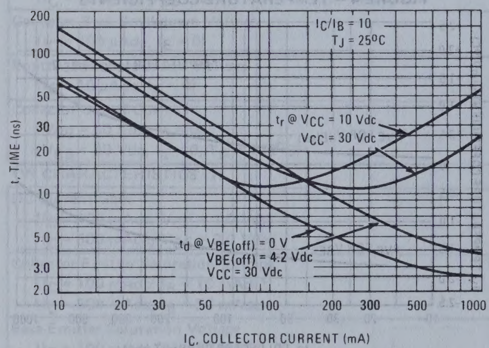


FIGURE 8 – TURN-OFF TIME

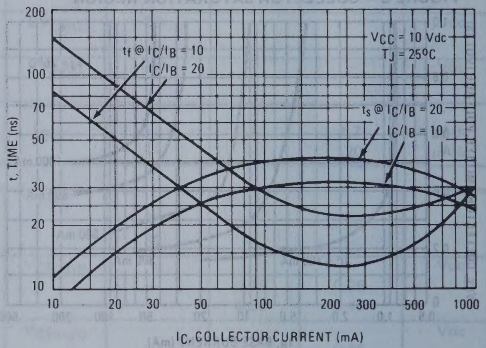


FIGURE 9 – SWITCHING TIME TEST CIRCUIT

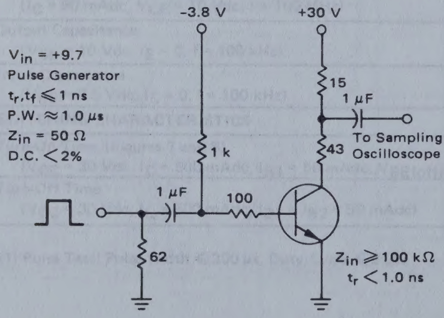
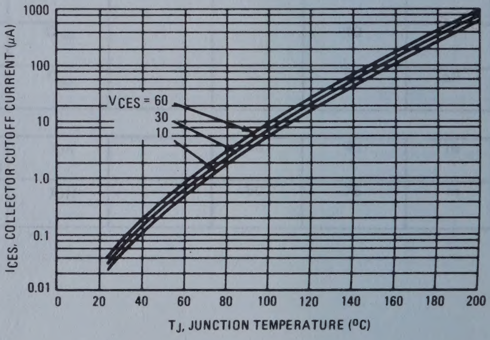

–3.8 V
+30 V
Vin = +9.7
Pulse Generator
tr,tf ≤ 1 ns
P.W. ≈ 1.0 μs
Zin = 50 Ω
D.C. < 2%
15
1 μF
To Sampling Oscilloscope
43
1 k
1 μF
100
62
Zin ≥ 100 kΩ
tr < 1.0 ns

FIGURE 10 – COLLECTOR CUTOFF CURRENT



MD3762 (SILICON)
MD3762F
MQ3762

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, and temperature compensation amplifiers.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.52 Vdc (Typ) @ I_C = 1.0 Adc
- DC Current Gain Specified — h_{FE} = 20 (Min) @ I_C = 1.0 Adc
- Fast Switching Times @ I_C = 1.0 Adc
  t_{on} = 40 ns (Max)
  t_{off} = 110 ns (Max)

PNP SILICON DUAL TRANSISTORS

MAXIMUM RATINGS

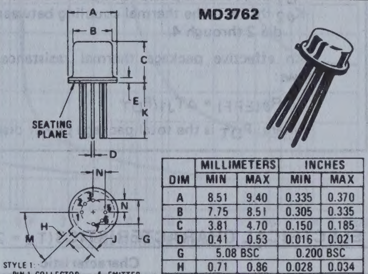
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25^\circ C$	P_D			mW
MD3762		600	650	
MD3762F		350	400	
MQ3762		400	600	
Derate above 25°C				mW/°C
MD3762		3.42	3.7	
MD3762F		2.0	2.28	
MQ3762		2.28	3.42	
Total Power Dissipation @ $T_C = 25^\circ C$	P_D			Watts
MD3762		2.1	3.0	
MD3762F		1.25	2.5	
MQ3762		1.0	4.0	
Derate above 25°C				mW/°C
MD3762		12	17.2	
MD3762F		7.15	14.3	
MQ3762		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD3762		292	270	
MD3762F		500	438	
MQ3762		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD3762		83.3	58.3	
MD3762F		140	70	
MQ3762		175	43.8	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD3762		85	40	
MD3762F		75	0	
MQ3762 (Q1-Q2)		57	0	
(Q1-Q3, Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD3762

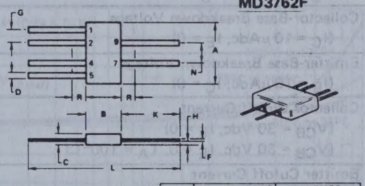


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

CASE 654-07

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

MD3762F

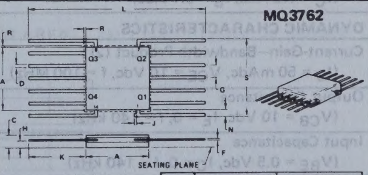


STYLE 1
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

CASE 610A-03

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

MQ3762



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

CASE 607-04

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	– –	– –	100 10	nAdc μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	20	40	–	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	–	0.52	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	–	1.05	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	220	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	8.5	20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	22	80	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figure 10)	t_d	–	5.0	10	ns
Rise Time	t_r	–	18	30	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figure 10)	t_s	–	45	80	ns
Fall Time	t_f	–	18	30	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – DC CURRENT GAIN

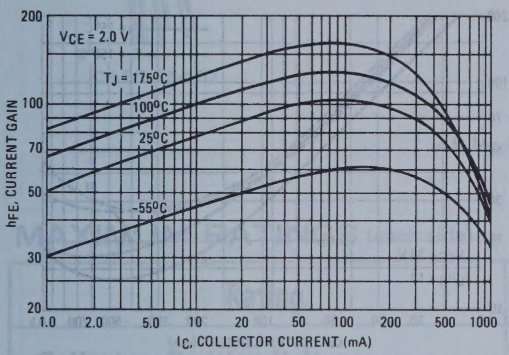


FIGURE 2 – COLLECTOR SATURATION REGION

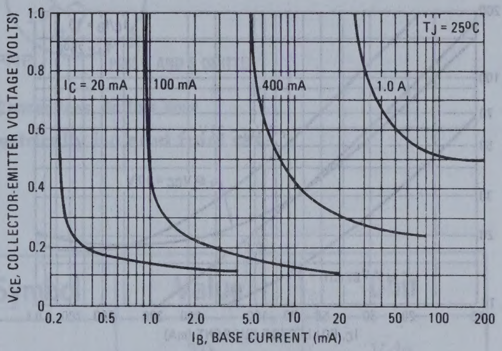


FIGURE 3 – "ON" VOLTAGE

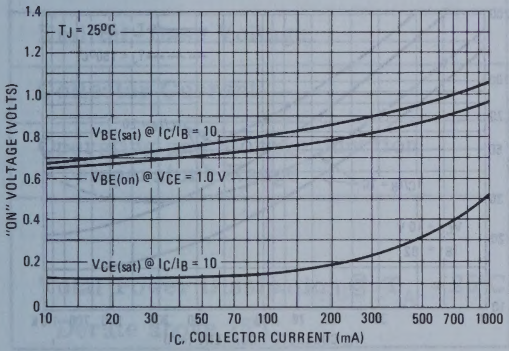


FIGURE 4 – TEMPERATURE COEFFICIENTS

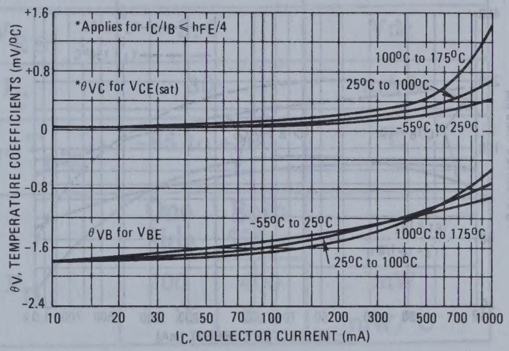


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

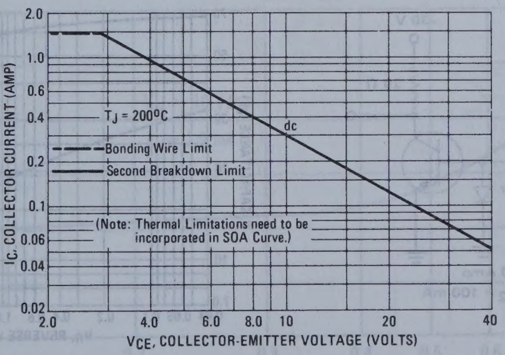


FIGURE 6 – TURN-ON TIME

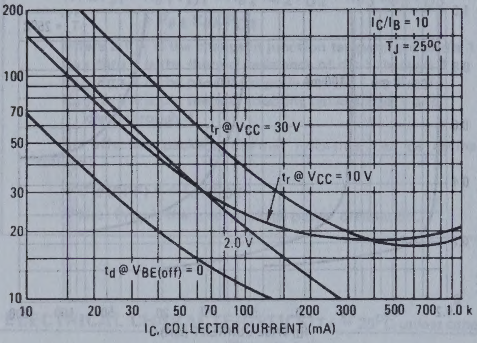


FIGURE 7 – RISE AND FALL TIME

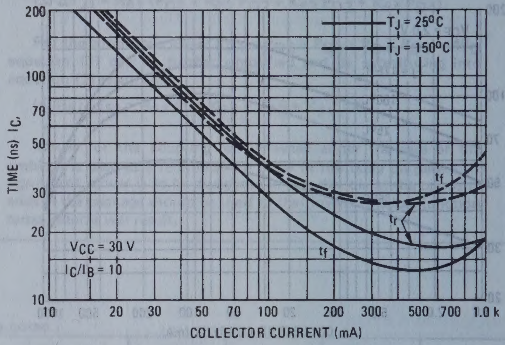


FIGURE 8 – STORAGE TIME

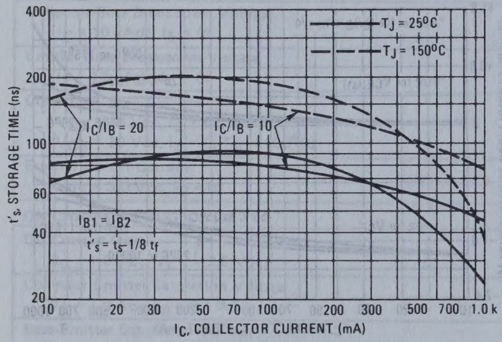


FIGURE 9 – FALL TIME

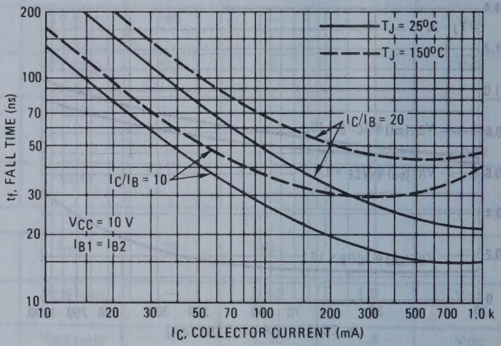


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

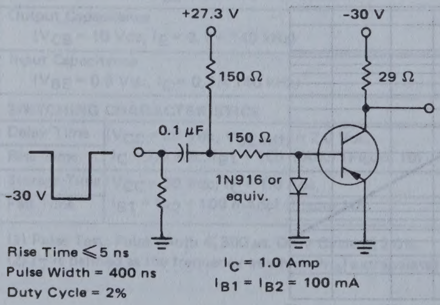
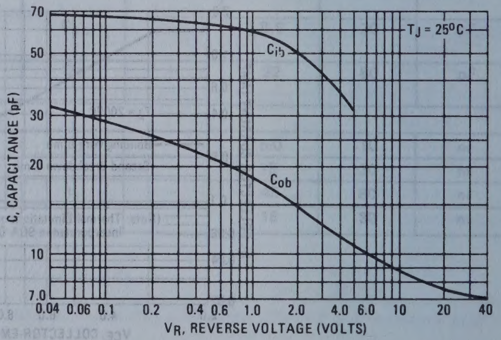

+27.3 V
-30 V
150 Ω
29 Ω
0.1 μF
150 Ω
1N916 or equiv.
-30 V
Rise Time ⩽ 5 ns
Pulse Width = 400 ns
Duty Cycle = 2%
I_C = 1.0 Amp
$I_{B1} = I_{B2}$ = 100 mA

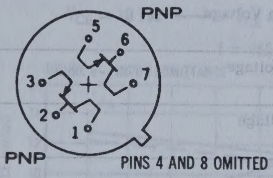
FIGURE 11 – CAPACITANCE



MD4957 (SILICON)

CASE 654-07

Dual PNP silicon annular transistor designed for high-frequency amplifier, oscillator, and mixer applications.



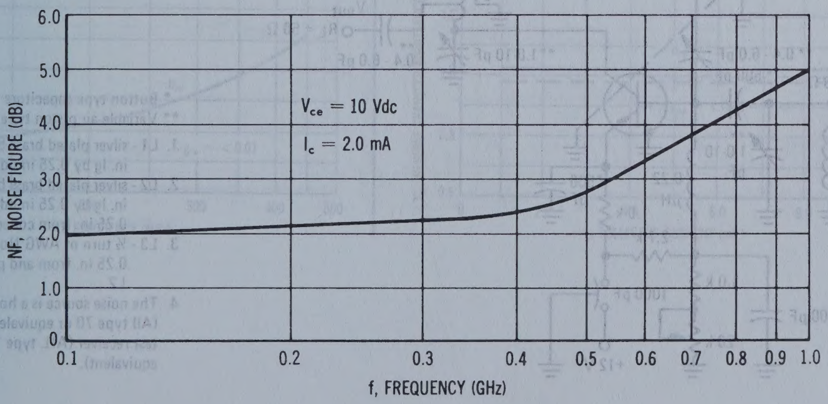
Pin Connections, Bottom View

All leads electrically isolated from case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Power Dissipation @ T_A = 25°C	P_D	200	400	mW
Derate above 25°C		1.15	2.3	mW/°C

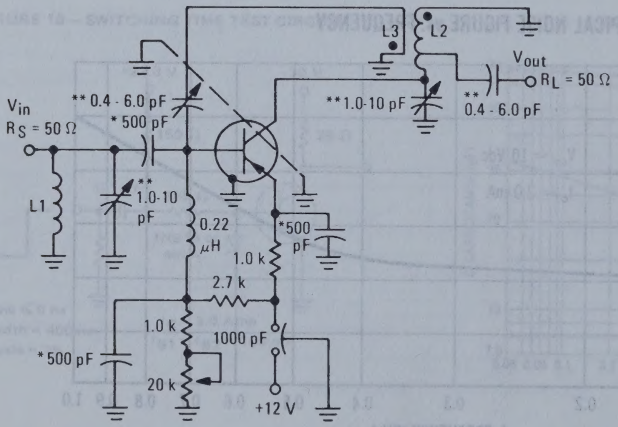
TYPICAL NOISE FIGURE vs. FREQUENCY



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	-	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	150	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1000	1500	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.4	0.8	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	-	200	-
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_c$	-	4.0	8.0	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz) Figure 1 (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 GHz)	NF	- -	2.6 5.0	- -	dB
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz) (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, R_S = 50 ohms, f = 1.0 GHz)	G_{pe}	- -	18 13	- -	dB

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



* Button type capacitors

** Variable air piston type capacitors

1. L1 - silver plated brass bar, 1.0 in. lg by 0.25 in od.
2. L2 - silver plated brass bar, 1.5 in. lg by 0.25 in od. Tap is 0.25 in. from collector
3. L3 - ½ turn of AWG No. 16 wire 0.25 in. from and parallel to L2.
4. The noise source is a hot-cold body (AIl type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

COMMON EMITTER Y PARAMETER VARIATIONS

Y PARAMETERS VS FREQUENCY

$V_{CE} = 10$ Vdc
$I_C = 2.0$ mA

FIGURE 2 — INPUT ADMITTANCE

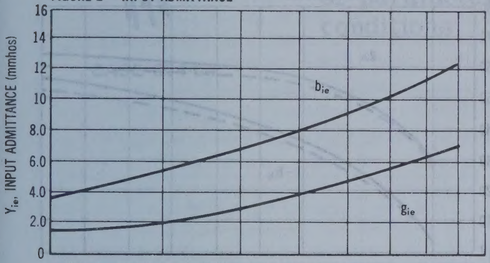


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

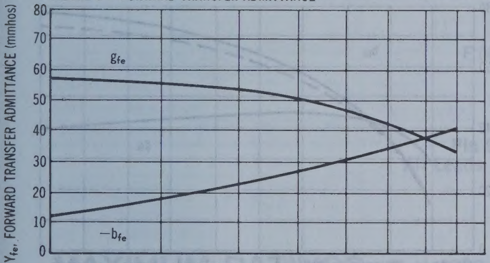


FIGURE 4 — OUTPUT ADMITTANCE

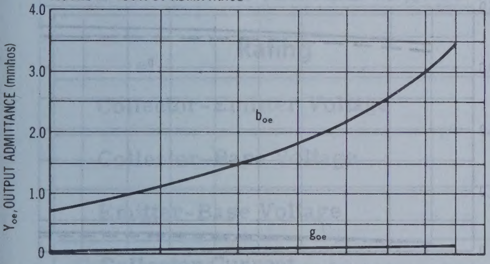
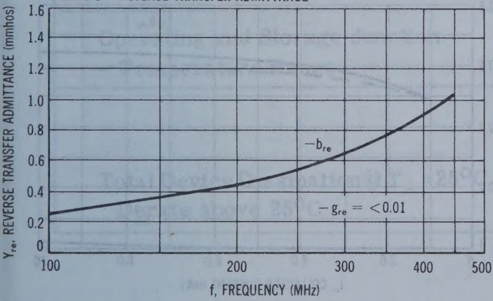


FIGURE 5 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS VS CURRENT

$V_{CE} = 10$ Vdc ——— $V_{CE} = 15$ Vdc — — —
f = 450 MHz

FIGURE 6 — INPUT ADMITTANCE

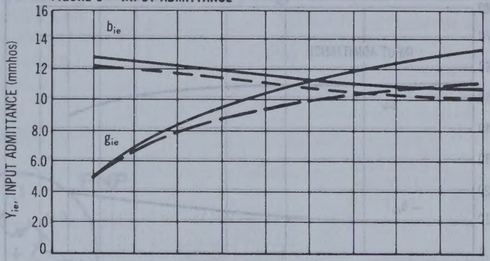


FIGURE 7 — FORWARD TRANSFER ADMITTANCE

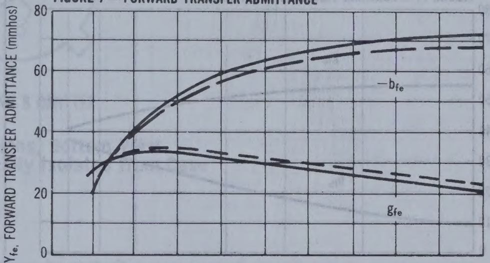


FIGURE 8 — OUTPUT ADMITTANCE

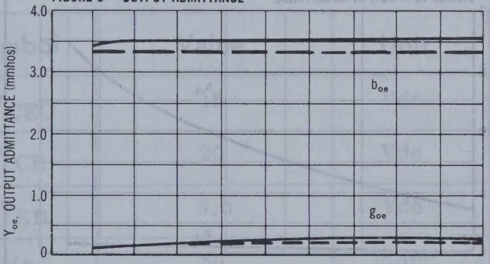
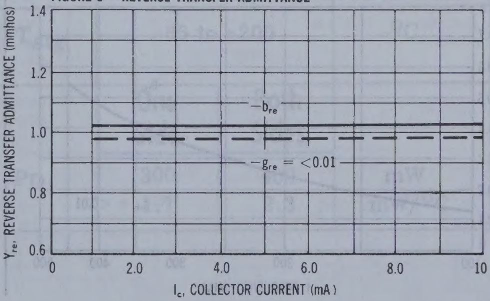


FIGURE 9 — REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

Y PARAMETERS versus FREQUENCY

$V_{CB} = 10$ Vdc
$I_C = 2.0$ mA

FIGURE 10 — INPUT ADMITTANCE

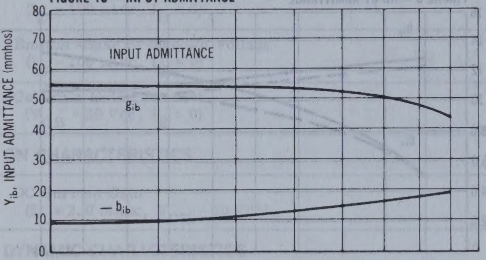


FIGURE 11 — FORWARD TRANSFER ADMITTANCE

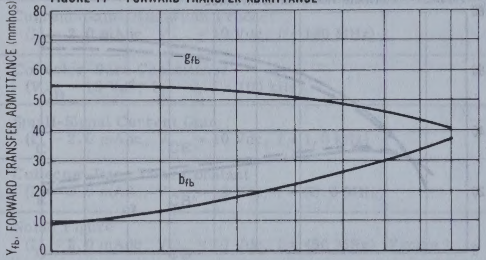


FIGURE 12 — OUTPUT ADMITTANCE

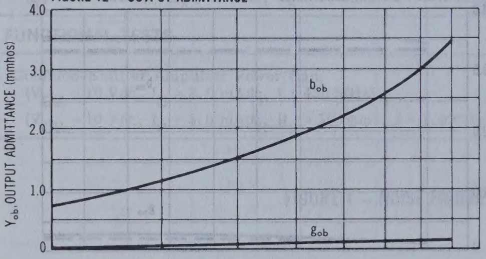
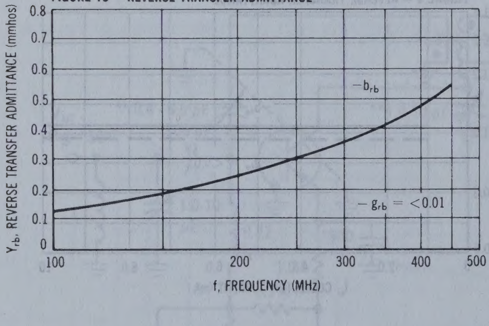


FIGURE 13 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS versus CURRENT

$V_{CB} = 10$ Vdc ——— $V_{CB} = 15$ Vdc — — —
f = 450 MHz

FIGURE 14 — INPUT ADMITTANCE

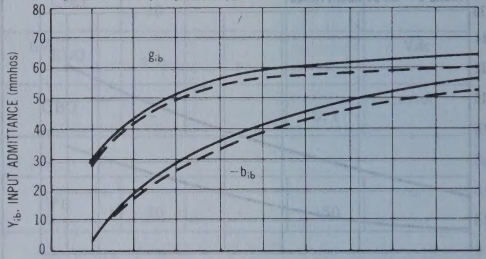


FIGURE 15 — FORWARD TRANSFER ADMITTANCE

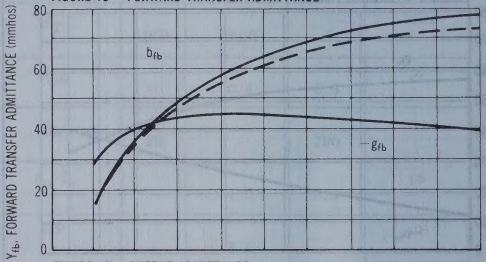


FIGURE 16 — OUTPUT ADMITTANCE

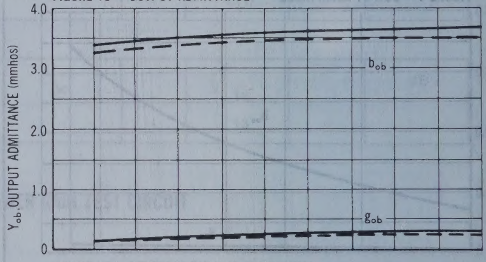
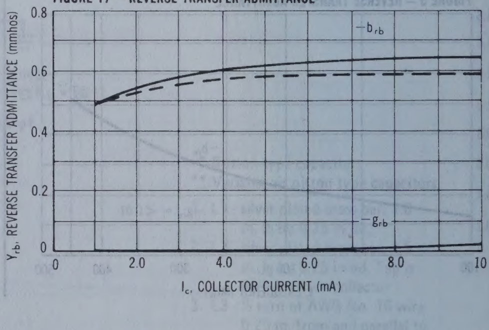
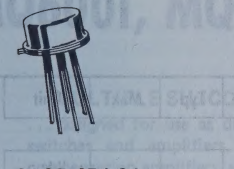


FIGURE 17 — REVERSE TRANSFER ADMITTANCE

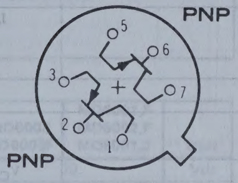


MD5000, A, B (SILICON)

Dual PNP silicon annular transistors designed for ultra-high frequency oscillator and amplifier applications and for differential-amplifier applications requiring a matched pair of transistors with a high degree of parameter uniformity under varying environmental conditions.



CASE 654-04



PINS 4 AND 8 OMITTED

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (T$_A$ = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	20		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	400 2.3	mW mW/°C

ELECTRICAL CHARACTERISTICS (each side) ; (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc, I_B = 0)	BV_{CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.010	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		—	—	1.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 3 mAdc, V_{CE} = 1 Vdc)	h_{FE}	20	50	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	—	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	900	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	—	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	—	2.0	pF
Noise Figure (I_C = 1 mAdc, V_{CE} = 6 Vdc, f = 60 MHz, R_S = 400 ohms)	NF	—	3.0	6.0	dB
FUNCTIONAL TEST					
Amplifier Power Gain (I_C = 6 mAdc, V_{CB} = 12 Vdc, R_G = R_L = 50 ohms, f = 200 MHz)	G_{pe}	15	20	—	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio* (I_C = 4 mAdc, V_{CE} = 10 Vdc) MD5000	h_{FE1}/h_{FE2}*	—	0.7	—	—
MD5000A		0.9	—	1.0	
MD5000B		0.8	—	1.0	
Base Voltage Differential (I_C = 4 mAdc, V_{CE} = 10 Vdc) MD5000	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5.0	—	mVdc
MD5000A		—	—	5.0	
MD5000B		—	—	10	
Base Voltage Differential Change (I_C = 4 mAdc, V_{CE} = 10 Vdc, T_A = -55 to +125°C) MD5000	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	—	μV/°C
MD5000A		—	—	10	
MD5000B		—	—	20	

*The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD6001, F (SILICON)
MD6002, F
MD6003, F
MQ6001, MQ6002

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose switches and amplifiers, front end detectors, and temperature compensation amplifiers, where complementary devices are required.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = 0.4$ Vdc (Max) @ $I_C = 150$ mAdc
- Fast Switching Times — $t_{on} = 28$ ns (Typ) and $t_{off} = 72$ ns (Typ)
- DC Current Gain Specified — 0.1 mAdc to 300 mAdc
- High Current-Gain—Bandwidth Product — $f_T = 340$ MHz (Typ) @ $I_C = 50$ mAdc

NPN, PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

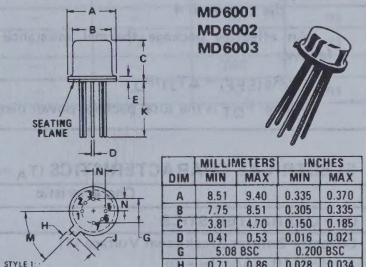
Rating	Symbol	MD6003 MD6003F	MD6001,F MD6002,F MQ6001,2	Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25^{\circ}C$	P_D			mW
MD6001,2,3		575	625	
MD6001F,2F,3F		350	400	
MQ6001,2		400	600	
Derate above 25°C				mW/°C
MD6001,2,3		3.29	3.57	
MD6001F,2F,3F		2.0	2.28	
MQ6001,2		2.28	3.42	
Total Power Dissipation @ $T_C = 25^{\circ}C$	P_D			Watts
MD6001,2,3		1.8	2.5	
MD6001F,2F,3F		1.0	2.0	
MQ6001,2		0.9	3.6	
Derate above 25°C				mW/°C
MD6001,2,3		10.3	14.3	
MD6001F,2F,3F		5.71	11.4	
MQ6001,2		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD6001,2,3		304	280	
MD6001F,2F,3F		500	438	
MQ6001,2		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD6001,2,3		97	70	
MD6001F,2F,3F		175	87.5	
MQ6001,2		195	48.8	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD6001,2,3		84	44	
MD6001F,2F,3F		75	0	
MQ6001,2 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD6001
MD6002
MD6003

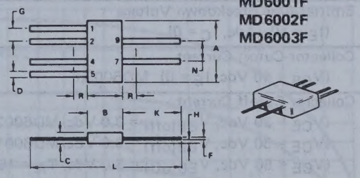


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

CASE 654-07

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	--	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

MD6001F
MD6002F
MD6003F

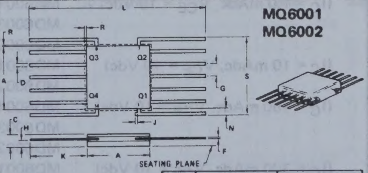


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

CASE 610A-03

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

MQ6001
MQ6002



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

CASE 607-04

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage	BV_{CBO}				Vdc
($I_C = 10\ \mu$Adc, $I_E = 0$) MD6003,F		50	–	–	
MD6001,F, MD6002,F, MQ6001, MQ6002		60	–	–	
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector-Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) MD6003,F	I_{CBO}	–	–	100	nA
Collector Cutoff Current	I_{CEV}				
($V_{CE} = 30$ Vdc, $V_{BE(off)} = 3.0$ Vdc) MD6003,F		–	–	30	nAdc
($V_{CE} = 50$ Vdc, $V_{EB(off)} = 3.0$ Vdc) MD6001,F,2,F, MQ6001,2		–	–	20	nAdc
($V_{CE} = 50$ Vdc, $V_{EB(off)} = 3.0$ Vdc, $T_A = 150^{\circ}C$) MD6001,F,2,F, MQ6001,2		–	–	30	μAdc
Base Cutoff Current	I_{BEV}				
($V_{CE} = 30$ Vdc, $V_{BE(off)} = 3.0$ Vdc) MD6003,F		–	–	50	nAdc
($V_{CE} = 50$ Vdc, $V_{EB(off)} = 3.0$ Vdc) MD6001,F,2,F,MQ6002,F		–	–	30	
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) MD6001,F, MQ6001		20	80	–	
MD6002,F, MQ6002		35	70	–	
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) MD6001,F, MQ6001		25	90	–	
MD6003,F		40	70	–	
MQ6002,F, MQ6002		50	100	–	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) MD6001,F, MQ6001		35	70	–	
MD6002,F, MQ6002		75	110	–	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) MD6001,F, MQ6001		40	–	120	
MD6003,F		70	110	–	
MD6002,F, MQ6002		100	200	300	
($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc) MD6001,F, MQ6001		20	–	–	
All Other Devices		30	90	–	
($I_C = 150$ mAdc, $V_{CE} = 1.0$ Vdc) MD6001,F, MQ6001		20	80	–	
MD6002,F, MQ6002		50	–	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc) All Devices		–	0.3	0.4	
($I_C = 300$ mAdc, $I_B = 30$ mAdc) MD6001, MD6002,F, MQ6001,2		–	0.59	1.4	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
($I_C = 150$ mAdc, $I_B = 15$ mAdc) All Devices		–	1.02	1.3	
($I_C = 300$ mAdc, $I_B = 30$ mAdc) MD6001, MD6002,F, MQ6001,2		–	1.25	2.0	

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

ELECTRICAL CHARACTERISTICS (continued)

DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	340	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	5.6	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	16	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) MD6001F,2F, MQ6001,2	t_{on}	–	28	60	ns
Delay Time		t_d	–	–	20	ns
Rise Time		t_r	–	–	40	ns
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) MD6001F,2F, MQ6001,2	t_{off}	–	72	350	ns
Storage Time		t_s	–	–	280	ns
Fall Time		t_f	–	–	70	ns

FIGURE 1 – DC CURRENT GAIN

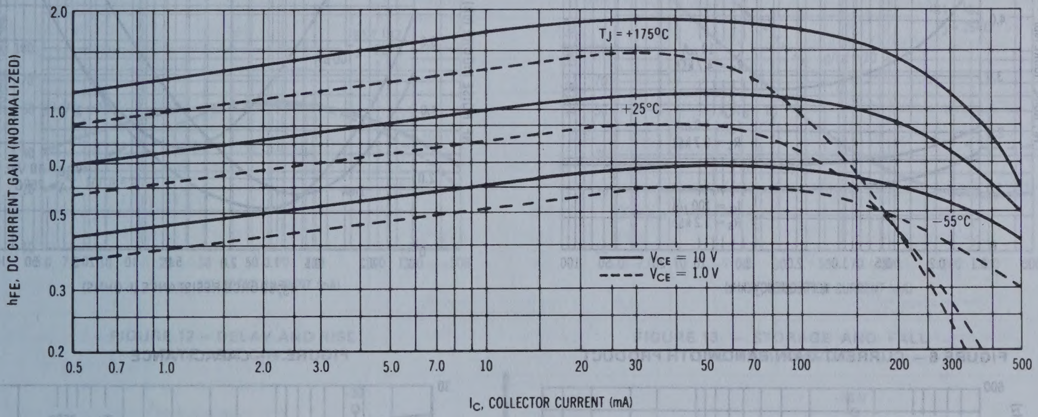


FIGURE 2 – "ON" VOLTAGES

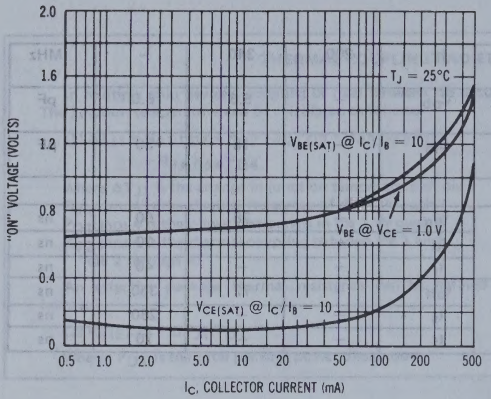
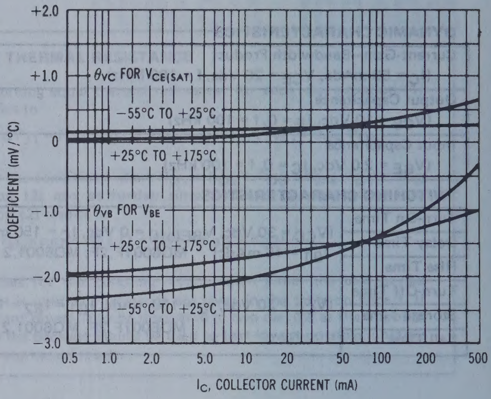


FIGURE 3 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 4 – FREQUENCY EFFECTS

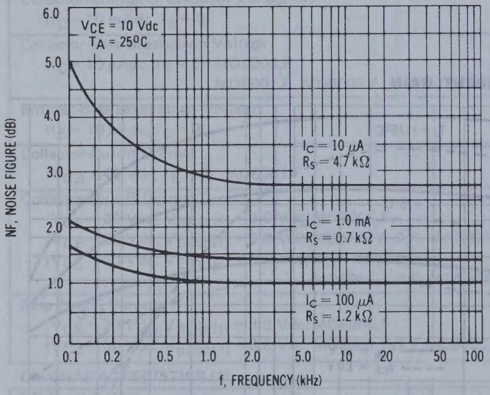


FIGURE 5 – SOURCE RESISTANCE EFFECTS

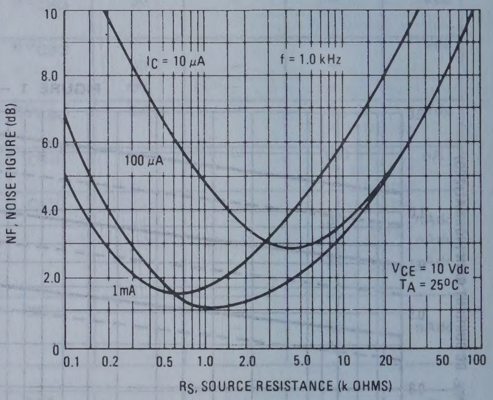


FIGURE 6 – CURRENT-GAIN BANDWIDTH PRODUCT

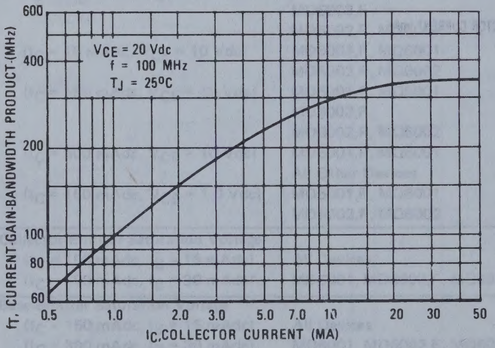


FIGURE 7 – CAPACITANCE

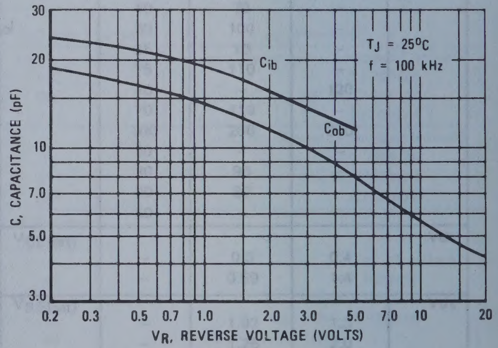


FIGURE 8 – TURN ON TIME

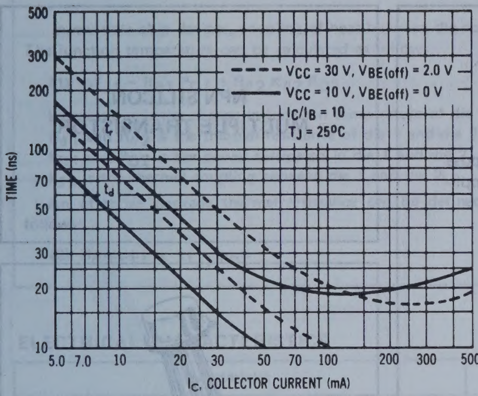


FIGURE 9 – CHARGE DATA

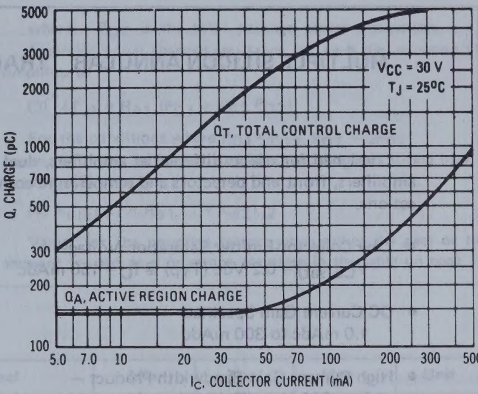


FIGURE 10 – STORAGE TIME

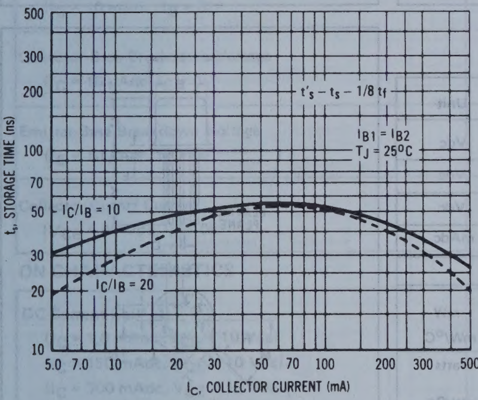


FIGURE 11 – FALL TIME

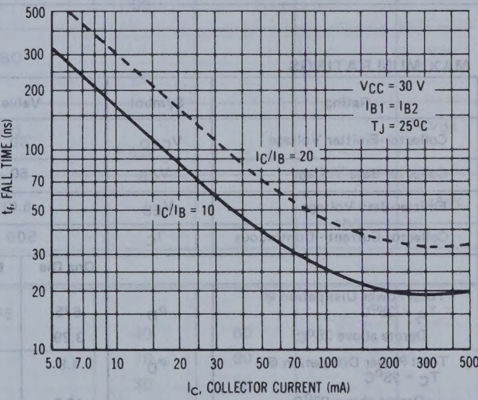


FIGURE 12 – DELAY AND RISE TIME TEST CIRCUIT

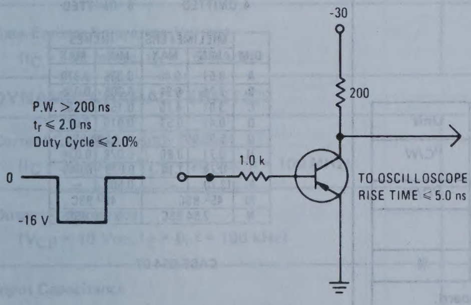
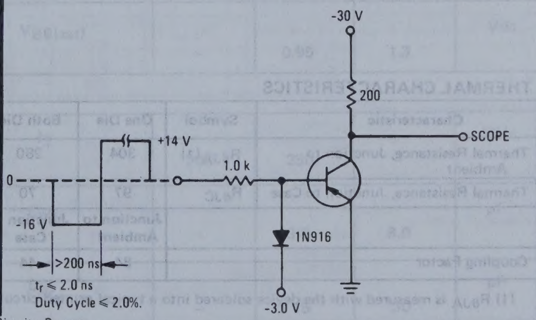

-30
200
P.W. > 200 ns
tr ≤ 2.0 ns
Duty Cycle ≤ 2.0%
0
-16 V
1.0 k
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns

FIGURE 13 – STORAGE AND FALL TIME TEST CIRCUIT


-30 V
200
SCOPE
+14 V
0
1.0 k
-16 V
>200 ns
tr ≤ 2.0 ns
Duty Cycle ≤ 2.0%.
1N916
-3.0 V

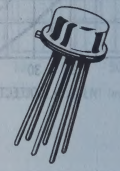
For NPN Test Circuits, Reverse Diode and all Voltage Polarities.

MULTIPLE SILICON ANNULAR TRANSISTOR

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 150 mAdc
- DC Current Gain Specified — 1.0 mAdc to 300 mAdc
- High Current-Gain-Bandwidth Product — f_T = 250 MHz (Typ) @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTOR



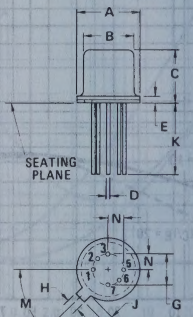
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$k_{\theta 2}$ is the thermal coupling between die 1 and die 2

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2}$, $P_{DT} = 2P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted)					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 40 70 30	 60 80 50	 – – –	–
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	–	0.2	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	–	0.95	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	250	–	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	3.5	8.0	pF
Input Capacitance ($V_{EB} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ib}	–	15	30	pF

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$

MD7001 (SILICON)
MD7001F
MQ7001

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors, and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- DC Current Gain Specified — 1.0 mAdc to 300 mAdc
- High Current-Gain-Bandwidth Product — f_T = 320 MHz (Typ) @ I_C = 20 mAdc

PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATING

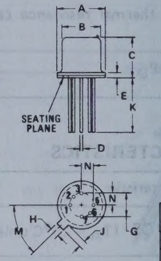
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	All Die	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD7001		600	650	
MD7001F		350	400	
MQ7001		400	600	
Derate above 25°C				mW/°C
MD7001		3.42	3.7	
MD7001F		2.0	2.28	
MQ7001		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD7001		2.1	3.8	
MD7001F		1.25	2.5	
MQ7001		1.0	4.0	
Derate above 25°C				mW/°C
MD7001		12	17.2	
MD7001F		7.15	14.3	
MQ7001		5.71	22.8	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

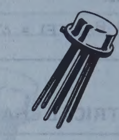
THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD7001		292	270	
MD7001F		500	438	
MQ7001		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD7001		83.3	58.3	
MD7001F		140	70	
MQ7001		175	43.8	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD7001		85	40	
MD7001F		75	0	
MQ7001 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD7001



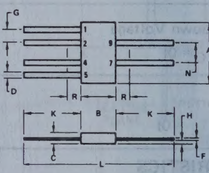


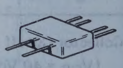
STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD7001F



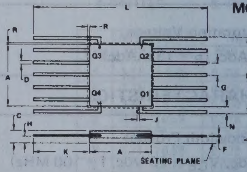


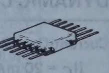
STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ7001





STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1\ \text{thru}\ 4}$ is the thermal resistance of die 1 through 4
$P_{D1\ \text{thru}\ 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2\ \text{thru}\ 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})\ /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	50	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		70	90	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		30	60	—	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.25	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	0.88	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	5.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	16	30	pF

(1) Pulse Test: Pulse Width $\leqslant$300 μs, Duty Cycle $\leqslant$2.0%.

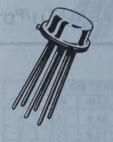
MD7002 (SILICON)
MD7002A
MD7002B

NPN SILICON ANNULAR MULTIPLE TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Matching Characteristics @ I_C = 100 μAdc –
  h_{FE1}/h_{FE2} = 0.75 (Min) – MD7002A
  = 0.85 (Min) – MD7002B
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.35 Vdc (Max) @ I_C = 10 mAdc
- DC Current Gain Specified @ 100 μAdc and 10 mAdc
- High Current-Gain–Bandwidth Product –
  f_T = 260 MHz (Typ) @ I_C = 5.0 mAdc

NPN SILICON MULTIPLE TRANSISTORS



MAXIMUM RATINGS

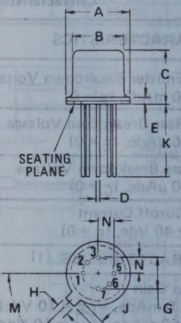
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector-Current	I_C	30	mAdc
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

		One Die	Both Die Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	575 3.29	625 3.57	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	2.5 14.3	Watts mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Both Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factors		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	--	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$K_{\theta 2}$ is the thermal coupling between die 1 and die 2.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to:

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2} = P_{DT} = 2 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in:

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (1)		h_{FE}				
(I_C = 100 μAdc, V_{CE} = 10 Vdc)			40	130	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			50	170	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.2	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	–	0.8	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 5.0 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	260	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.6	6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	2.3	8.0	pF
MATCHING CHARACTERISTICS						
DC Current Gain Ratio (2) (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD7002A	h_{FE1}/h_{FE2}	0.75	–	1.0	
	MD7002B		0.85	–	1.0	
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD7002A	$\lvert V_{BE1}-V_{BE2}\rvert$	–	–	25	mVdc
	MD7002B		–	–	15	

(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD7003, F (SILICON)
MD7003A, AF
MD7003B
MQ7003

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as high-gain, low-noise differential amplifiers, front end detectors, and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Typ) @ I_C = 10 mAdc
- DC Current Gain Specified @ 100 μAdc and 10 mAdc
- High Current-Gain—Bandwidth Product — f_T = 300 MHz (Typ) @ I_C = 5.0 mAdc

PNP SILICON DUAL TRANSISTORS

MAXIMUM RATINGS

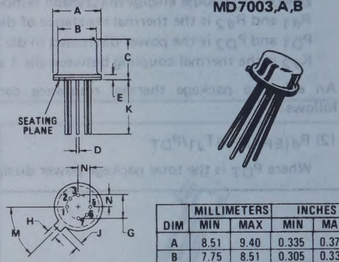
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD7003,A,B		550	600	
MD7003F,AF		350	400	
MQ7003		400	600	
Derate above 25°C				mW/°C
MD7003,A,B		3.14	3.42	
MD7003F,AF		2.0	2.28	
MQ7003		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD7003,A,B		1.4	2.0	
MD7003F,AF		0.7	1.4	
MQ7003		0.7	2.8	
Derate above 25°C				mW/°C
MD7003,A,B		8.0	11.4	
MD7003F,AF		4.0	8.0	
MQ7003		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD7003,A,B		319	292	
MD7003F,AF		500	438	
MQ7003		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD7003,A,B		125	87.5	
MD7003F,AF		250	125	
MQ7003		250	62.6	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD7003,A,B		83	40	
MD7003F,AF		75	0	
MQ7003 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD7003,A,B

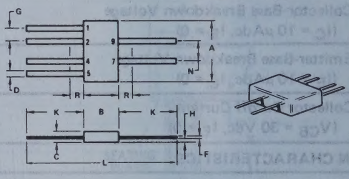


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD7003F,AF

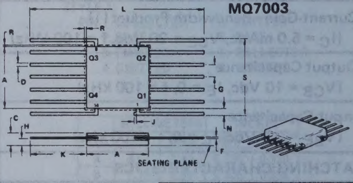


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	·0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ7003



STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\ \mu Adc$, $I_B = 0$)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu Adc$, $I_E = 0$)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)	h_{FE}				–
($I_C = 100\ \mu Adc$, $V_{CE} = 10$ Vdc)		40	350	–	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	350	–	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	–	0.25	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	–	0.6	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	300	–	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	3.0	6.0	pF
Input Capacitance ($V_{BE} = 2.0$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ib}	–	2.0	8.0	pF
Noise Figure ($I_C = 100\ \mu Adc$, $V_{CE} = 10$ Vdc, $R_S = 3.0$ k Ohms, f = 10 Hz to 15.7 kHz)	NF	–	2.0	–	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (2) MD7003A,AF	h_{FE1}/h_{FE2}	0.75	–	1.0	–
($I_C = 100\ \mu Adc$, $V_{CE} = 10$ Vdc) MD7003B		0.85	–	1.0	
Base-Emitter Voltage Differential MD7003A,AF	$\lvert V_{BE1}-V_{BE2}\rvert$	–	–	25	mV
($I_C = 100\ \mu Adc$, $V_{CE} = 10$ Vdc) MD7003B		–	–	15	

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD7004, F (SILICON)
MQ7004

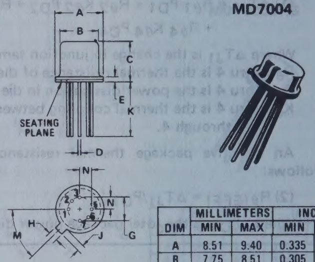
MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual high speed switches, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 10 mAdc
- Low Output Capacitance —
  C_{ob} = 2.5 pF (Typ) @ V_{CB} = 5.0 Vdc
- High Current-Gain—Bandwidth Product —
  f_T = 675 MHz (Typ) @ I_C = 10 mAdc

NPN SILICON DUAL TRANSISTORS

MD7004

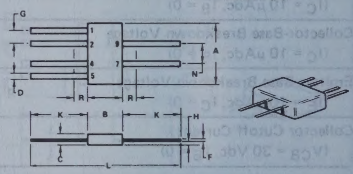


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD7004F

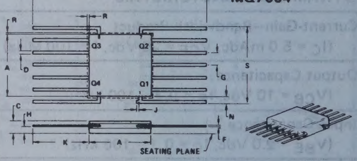


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ7004



STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	13		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ T_A = 25°C	P_D			mW
MD7004		550	600	
MD7004F		350	400	
MQ7004		400	600	
Derate above 25°C				mW/°C
MD7004		3.14	3.42	
MD7004F		2.0	2.28	
MQ7004		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			Watts
MD7004		1.4	2.0	
MD7004F		0.7	1.4	
MQ7004		0.7	2.8	
Derate above 25°C				mW/°C
MD7004		8.0	11.4	
MD7004F		4.0	8.0	
MQ7004		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD7004		319	292	
MD7004F		500	438	
MQ7004		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD7004		125	87.5	
MD7004F		250	125	
MQ7004		250	62.6	
		Junction to Ambient	Junction to Case	
Coupling Factors				%
MD7004		83	40	
MD7004F		75	0	
MQ7004 (Q1-Q2)		57	0	
(Q1-Q2 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	13	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 2.0 Vdc)		30	100	–	
(I_C = 50 mAdc, V_{CE} = 2.0 Vdc)		30	55	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_E = 1.0 mAdc)	$V_{CE(sat)}$	–	0.2	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.7	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	–	675	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	2.5	4.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	2.4	4.0	pF

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

MD7007, A, B (SILICON)
MD7007F, BF
MQ7007

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 50 mAdc
- DC Current Gain Specified — 100 μAdc to 50 mAdc
- High Current-Gain—Bandwidth Product — f_T = 600 MHz (Typ) @ I_C = 10 mAdc

NPN SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

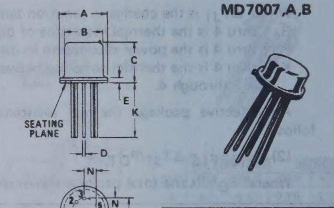
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ T_A = 25°C	P_D			
MD7007,A,B		575	625	mW
MD7007F,BF		350	400	
MQ7007		400	600	
Derate above 25°C				
MD7007,A,B		3.29	3.57	mW/°C
MD7007F,BF		2.0	2.28	
MQ7007		2.28	3.42	
Total Power Dissipation @ T_C = 25°C	P_D			
MD7007,A,B		1.8	2.5	Watts
MD7007F,BF		1.0	2.0	
MQ7007		0.9	3.6	
Derate above 25°C				
MD7007,A,B		10.3	14.3	mW/°C
MD7007F,BF		5.71	11.4	
MQ7007		5.13	20.5	
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

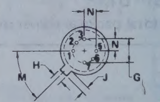
THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			°C/W
MD7007,A,B		304	280	
MD7007F,BF		500	438	
MQ7007		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			°C/W
MD7007,A,B		97	70	
MD7007F,BF		175	87.5	
MQ707		195	48.8	
		Junction to Ambient	Junction to Case	Unit
Coupling Factors				%
MD7007,A,B		84	44	
MD7007F,BF		75	0	
MQ7007 (Q1-Q2)		57	0	
(Q1-Q2 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD7007,A,B



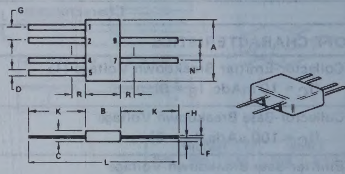


STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD7007F,BF

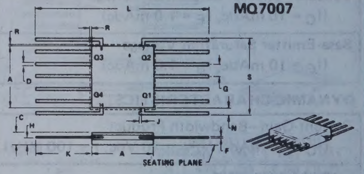


STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ7007



STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		30	110	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		30	130	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		30	75	–	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)		15	25	–	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	0.38	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	0.9	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	600	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	4.0	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	3.8	10	pF
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (2)	h_{FE1}/h_{FE2}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD7007A		0.75	–	1.0	
MD7007B		0.85	–	1.0	
Base-Emitter Voltage Differential	$\lvert V_{BE1}/V_{BE2}\rvert$				mVdc
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MD7007A		–	–	20	
MD7007B		–	–	10	

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD7021 (SILICON)
MD7021F
MQ7021

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, switches, dual general-purpose amplifiers, front end detectors, and temperature compensation amplifiers.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = 0.35$ Vdc (Max) @ $I_C = 10$ mAdc
- Fast Switching Times — $t_{on} = 28$ ns (Typ) $t_{off} = 72$ ns (Typ)
- DC Current Gain Specified — 100 μAdc and 10 mAdc
- High Current-Gain—Bandwidth Product — $f_T = 320$ MHz (Typ) @ $I_C = 5.0$ mAdc

NPN/PNP SILICON MULTIPLE TRANSISTORS

MAXIMUM RATINGS

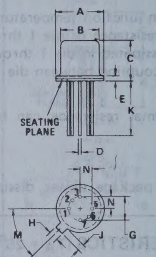
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector-Current — Continuous	I_C	50		mAdc
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25^oC$	P_D			mW
MD7021		550	600	
MD7021F		350	400	
MQ7021		400	600	
Derate above 25^oC				mW/^oC
MD7021		3.14	3.42	
MD7021F		2.0	2.28	
MQ7021		2.28	3.42	
Total Power Dissipation @ $T_C = 25^oC$	P_D			Watts
MD7021		1.4	2.0	
MD7021F		0.7	1.4	
MQ7021		0.7	2.8	
Derate above 25^oC				mW/^oC
MD7021		8.0	11.4	
MD7021F		4.0	8.0	
MQ7021		4.0	16	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

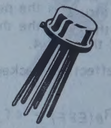
THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)			$^oC/W$
MD7021		319	292	
MD7021F		500	438	
MQ7021		438	292	
Thermal Resistance, Junction to Case	$R_{\theta JC}$			$^oC/W$
MD7021		125	87.5	
MD7021F		250	125	
MQ7021		250	62.6	
		Junction to Ambient	Junction to Case	
Coupling Factor				%
MD7021		83	40	
MD7021F		75	0	
MQ7021 (Q1-Q2)		57	0	
(Q1-Q3 or Q1-Q4)		55	0	

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

MD7021



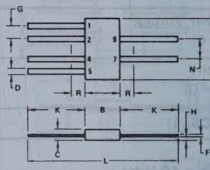


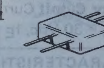
STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MD7021F



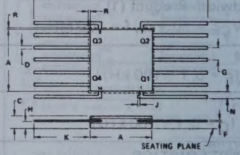


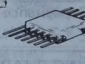
STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

MQ7021





STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})\ /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

(Characteristics apply to corresponding flat package, and quad type number.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		40	65	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	70	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (1)	$V_{CE(sat)}$	–	–	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	320	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	–	6.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	–	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 Adc)	t_{on}	–	28	–	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	–	72	–	ns

(1) Pulse Test: Pulse Width $\leqslant$300 μs, Duty Cycle $\leqslant$2.0%.

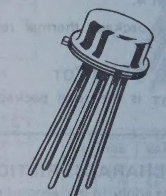
MD8001 (SILICON)
MD8002
MD8003

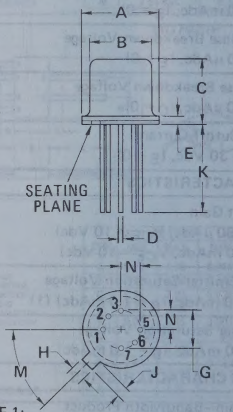
MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front-end detectors and temperature compensation applications.

- Excellent Audio Amplifier Direct Coupled Input Devices.
- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 40 Vdc (Min) — MD8001
  50 Vdc (Min) — MD8002
  60 Vdc (Min) — MD8003

NPN SILICON MULTIPLE TRANSISTORS





STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	--	0.500	–
M	45^0 BSC		45^0 BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage MD8001 MD8002 MD8003	V_{CEO}	 40 50 60		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die Equal Power	
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	575 3.29	625 3.57	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.8 10.3	2.5 14.3	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die Max	Both Die Equal Power Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	304	280	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97	70	$^oC/W$
		Junction to Ambient	Junction to Case	
Coupling Factor		84	44	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ and $R_{\theta 2}$ is the thermal resistance of die 1 and die 2
P_{D1} and P_{D2} is the power dissipated in die 1 and die 2
$k_{\theta 2}$ is the thermal coupling between die 1 and die 2

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2})$

For the conditions where $P_{D1} = P_{D2}$, $P_{DT} = 2P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2})/2$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}				Vdc
MD8001		40	–	–	
MD8002		50	–	–	
MD8003		60	–	–	
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	200	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (1) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	–	260	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	2.6	–	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	2.3	–	pF
MATCHING CHARACTERISTICS					
Base Voltage Differential (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	$\lvert V_{BE1} - V_{BE2} \rvert$	–	–	15	mVdc

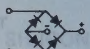
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MDA100 Series

MINIATURE INTEGRAL DIODE ASSEMBLIES

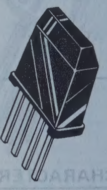
. . . with diffused-silicon dice interconnected and encapsulated into voidless rectifier bridge circuits.

- High Resistance to Shock and Vibration
- High Dielectric Strength
- Economical



SINGLE-PHASE FULL-WAVE BRIDGE

1.5 AMPERES
50-1000 VOLTS

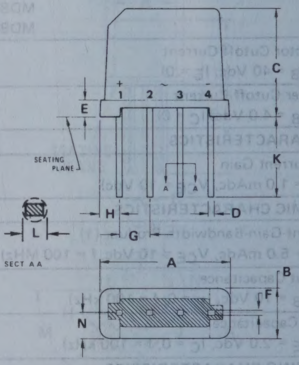


MAXIMUM RATINGS

Rating (Per Diode)	Symbol	MDA							Unit
		100	101	102	104	106	108	110	
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
DC Output Voltage									
Resistive Load	Vdc	32	64	127	255	382	510	640	Volts
Capacitive Load	Vdc	50	100	200	400	600	800	1000	Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase bridge operation, resistive load, 60 Hz, $T_A = 55^oC$)	I_O	1.5							Amp
Non-Repetitive Peak Surge Current (Preceded and followed by rated current and voltage, $T_A = 55^oC$)	I_{FSM}	45 (for 1 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150							^oC

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode) ($i_F = 2.4$ Amp, $T_J = 25^oC$)	v_F	0.95	1.05	Volts
Reverse Current (Rated V_{RRM} applied to ac terminals, + and − terminals open, $T_A = 25^oC$)	I_R	—	10	µA



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.00	17.53	0.630	0.690
B	5.59	7.11	0.220	0.280
C	13.59	13.97	0.535	0.550
D	0.69	0.94	0.027	0.037
E	1.91	2.16	0.075	0.085
F	0.56	0.71	0.022	0.028
G	3.81 BSC		0.150 BSC	
H	2.29	3.05	0.090	0.120
K	7.62	12.70	0.300	0.500
L	0.89	1.14	0.035	0.045
N	2.79	3.56	0.110	0.140

CASE 282-02

MECHANICAL CHARACTERISTICS

CASE: Plastic-Encapsulated

POLARITY: Terminal-designation on case
+DC output
−DC output
AC input

MOUNTING POSITION: Any

WEIGHT: 2.2 grams (approx)

TERMINALS: Readily solderable connections, corrosion resistant.

MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 1 — AMBIENT TEMPERATURE DERATING

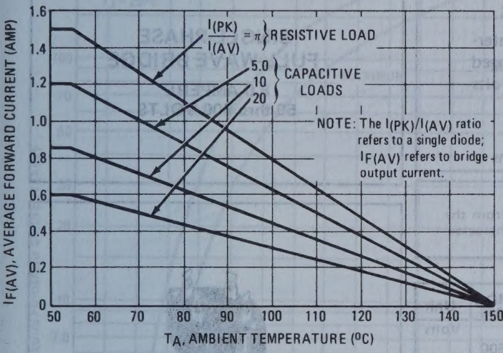
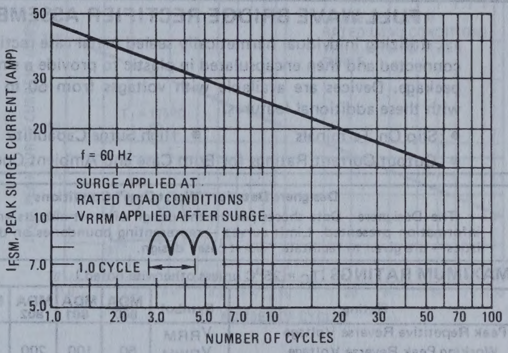


FIGURE 2 — MAXIMUM SURGE CURRENT CAPABILITY



SINGLE DIODE CHARACTERISTICS

FIGURE 3 — MAXIMUM FORWARD VOLTAGE

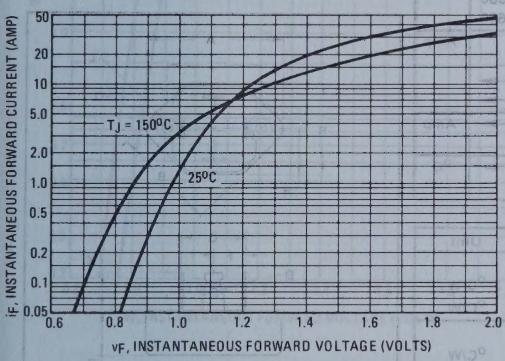


FIGURE 4 — JUNCTION CAPACITANCE

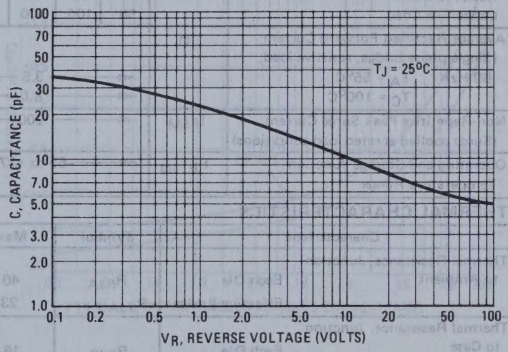


FIGURE 5 — FORWARD RECOVERY TIME

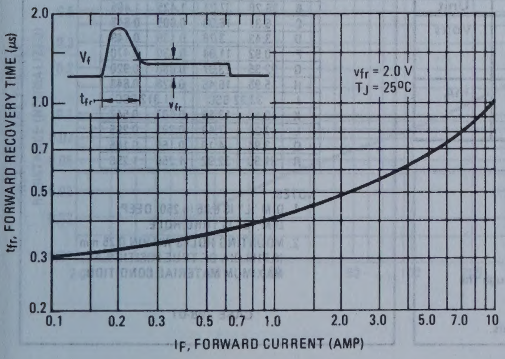
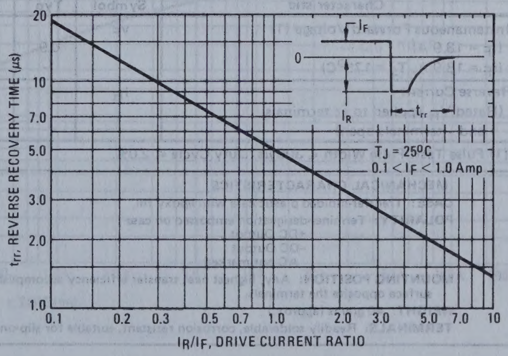


FIGURE 6 — REVERSE RECOVERY TIME



MDA800, MDA801
MDA802, MDA804
MDA806

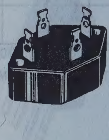
Designers Data Sheet

FULL WAVE BRIDGE RECTIFIER ASSEMBLIES

. . . utilizing inidvidual hermetically sealed metal case rectifiers interconnected and then encapsulated in plastic to provide a single rugged package. Devices are available with voltages from 50 to 600 Volts with these additional features.

- Slip On Terminals
- High Surge Capability
- Output Current Ratings for Both Case and Ambient Conditions

SINGLE-PHASE
FULL-WAVE BRIDGE
8.0 AMPERE
50 thru 600 VOLTS

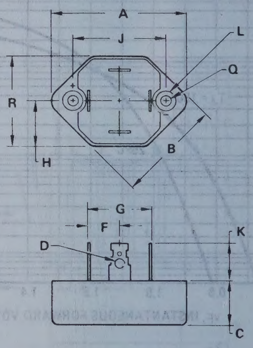


Designers Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted.)

Rating	Symbol	MDA 800	MDA 801	MDA 802	MDA 804	MDA 806	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
DC Output Voltage Resistive Load Capacitive Load	Vdc	30 50	62 100	124 200	250 400	380 600	Volts
Average Rectified Forward Current (Single phase bridge, resistive load, 60 Hz) T_A = 55°C T_C = 100°C	I_O	← 3.5 → ← 8.0 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 200 →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +175 →					°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	47.75	48.89	1.880	1.925
B	36.20	37.21	1.425	1.465
C	15.37	16.38	0.605	0.645
D	3.43	3.78	0.135	0.149
F	10.92	11.94	0.430	0.470
G	22.35	23.37	0.880	0.920
H	15.95	16.46	0.628	0.648
J	33.32 BSC		1.312 BSC	
K	12.88	13.89	0.507	0.547
L	7.24	7.49	0.285	0.295
Q	3.94	4.19	0.155	0.165
R	31.90	32.92	1.256	1.296

NOTES:
1. DIM "L" IS 6.35 (0.250) DEEP; DIM "Q" IS THRU HOLE.
2. MOUNTING HOLES WITHIN 0.25 mm (0.010) DIA OF TRUE POSITION AT MAXIMUM MATERIAL CONDITION.

CASE 298-01

THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	Each Die Effective Bridge	$R_{\theta JA}$ $R_{\theta JA(EFF)}$	40 23	°C/W °C/W
Thermal Resistance, Junction to Case	Each Die Effective Bridge	$R_{\theta JC}$ $R_{\theta JC(EFF)}$	16 5.6	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (1) (i_F = 18.9 A) (i_F = 18.9 A, T_J = 175°C)	v_F	 0.9 —	 1.0 0.85	Volts
Reverse Current (Rated V_R applied to ac terminals, + and − terminals open)	I_R	—	0.5	mA

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic case with epoxy fill.

POLARITY: Terminal-designation embossed on case
+DC Output
−DC Output
AC not marked

MOUNTING POSITION: Any, highest heat transfer efficiency accomplished through the surface opposite the terminals.

WEIGHT: 40 grams (approx.)

TERMINALS: Readily solderable, corrosion resistant, suitable for slip-on terminals.

FIGURE 1 – FORWARD VOLTAGE

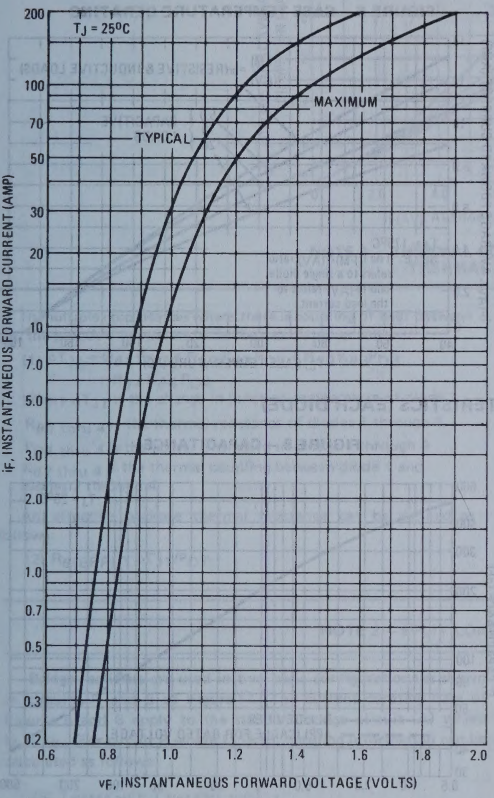


FIGURE 2 – MAXIMUM SURGE CAPABILITY

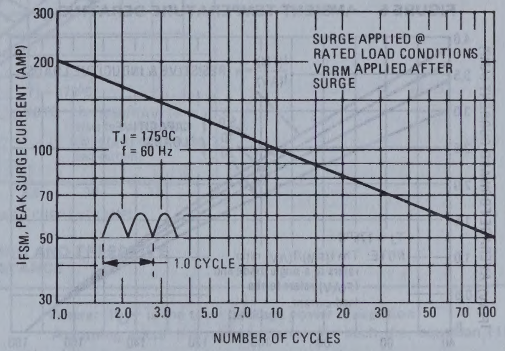


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

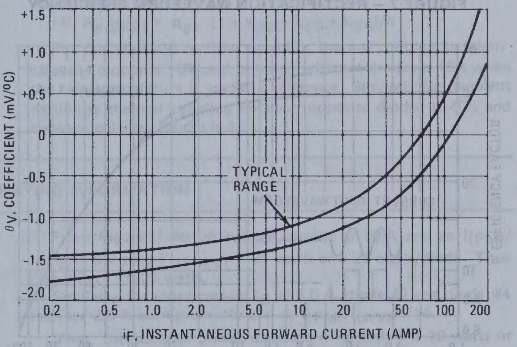
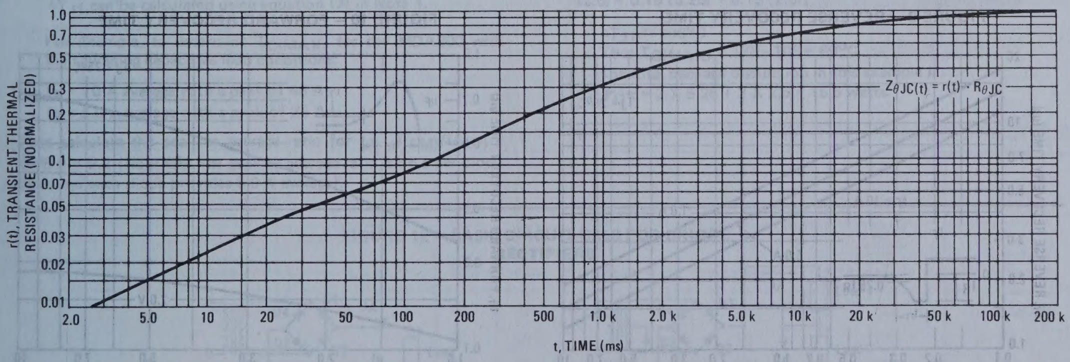


FIGURE 4 – TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – AMBIENT TEMPERATURE DERATING

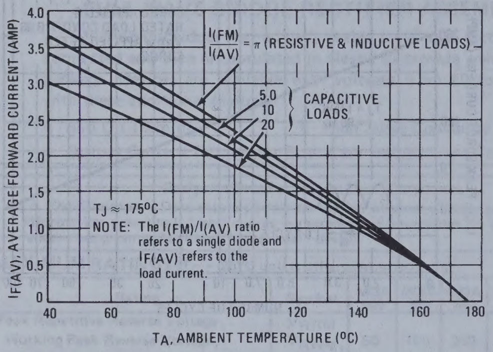
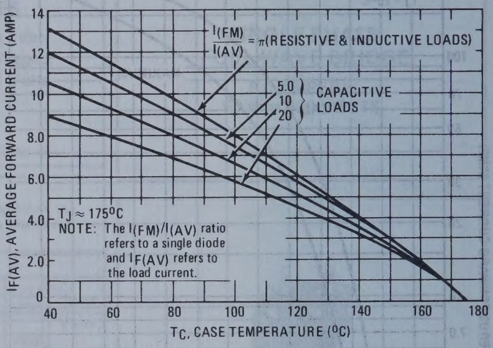


FIGURE 6 – CASE TEMPERATURE DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 – RECTIFICATION WAVEFORM EFFICIENCY

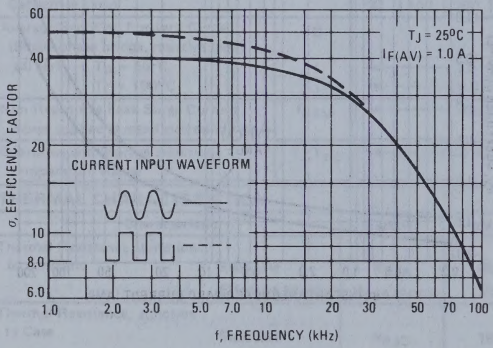


FIGURE 8 – CAPACITANCE

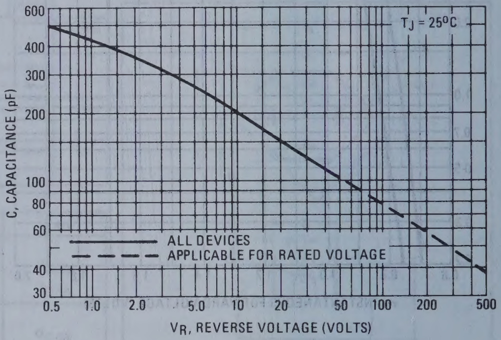


FIGURE 9 – REVERSE RECOVERY TIME

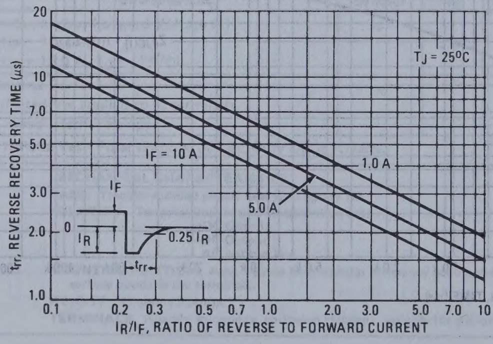


FIGURE 10 – FORWARD RECOVERY TIME

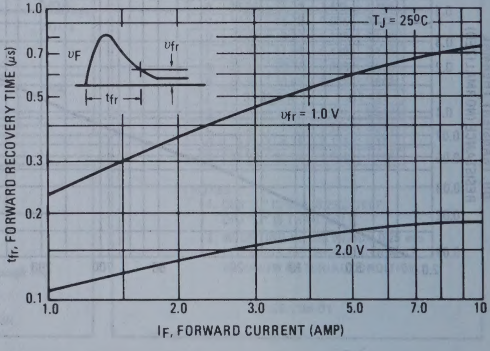
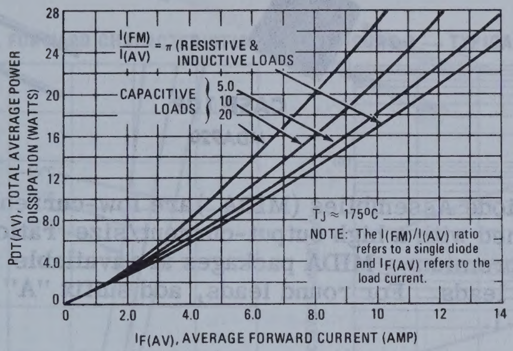


FIGURE 11 – POWER DISSIPATION FIGURE



NOTE 1 – THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D2} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1

$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of diodes 1 through 4.

$P_{D1 \text{ thru } 4}$ is the power dissipated in diodes 1 through 4

$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the condition where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_{D1}$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

For the MDA800 rectifier assembly, thermal coupling between opposite diodes is 10% and between adjacent diodes is 15% when the case temperature is used as a reference. Similarly for ambient mounting thermal coupling between opposite diodes is 40% and between adjacent diodes is 45%.

NOTE 2 – SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown in circuits A and B of Figure 12. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

(5) $T_{R(MAX)} = T_{J(MAX)} - \Delta T_{J1}$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the MDA800 with the following capacitive load conditions:

I_A = 10 A average with a peak of 46 A
I_B = 5.0 A average with a peak of 35 A

First calculate the peak to average ratio for I_A. $I_{(FM)}/I_{(AV)}$ = 46/5.0 = 9.2 (Note that the peak to average ratio is on a per diode basis and each diode provides 5.0 A average).

From Figure 11, for an average current of 10 A and an $I_{(FM)}/I_{(AV)} = 9.2$ read $P_{DT(AV)} = 21$ watts or 5.25 watts/diode. Thus $P_{D1} = P_{D3} = 5.25$ watts.

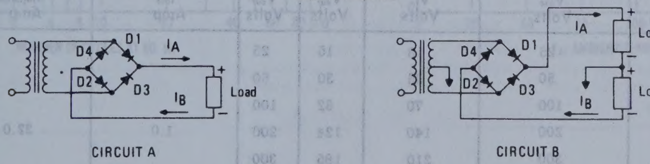
Similarly, for a load current I_B of 5.0 A, diode #2 and diode #4 each see 2.5 A average resulting in an $I_{(FM)}/I_{(AV)} = 14$.

Thus, the package power dissipation for 5.0 A is 10 watts or 2.5 watts/ diode. $\therefore P_{D2} = P_{D4} = 2.5$ watts.

The maximum junction temperature occurs in diodes #1 and #3. From equation (3) for diode #1 $\Delta T_{J1} = 16\ [5.25 + 0.1 (2.5) + 0.15 (5.25) + 0.15 (2.5)]$

$\Delta T_{J1} \approx 106°C$
Thus $T_{C(MAX)} = 175 - 106 = 69°C$
The total package dissipation in this example is:
$P_{DT} = 2 \times 5.25 + 2 \times 2.5 = 15.5$ watts.

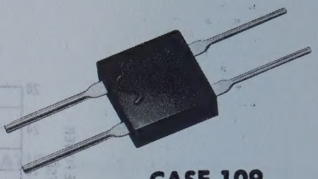
FIGURE 12 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



SILICON
MINIATURE DIODE ASSEMBLIES

MDA920 series

CASE 108
MDA920



CASE 109
MDA920A

Miniature Integral Diode Assemblies (MIDA) are low-current rectifier circuit configurations designed with a high output-current/size ratio for applications where space is at a premium. MIDA packages are available with flat ribbon leads and with round leads. For round leads, add suffix "A" to type number. Example, MDA920A-1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage Drop per Cell (I_F = 500 mA Continuous)	V_F	1.2	Vdc
Maximum Reverse Current (Figure 2) (V_R = Rated V_{RM}) 25°C 100°C	I_R	 60 600	μAdc

MECHANICAL CHARACTERISTICS

CASE: Transfer molded plastic encapsulation.

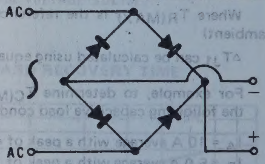
FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Embossed symbol on 4-lead devices.
Terminal designation by color dots on 3-lead devices:
AC input — yellow
+DC output — red
−DC output — white

MOUNTING POSITION: Any.

WEIGHT (approx.): 0.4 gram.

SINGLE PHASE FULL WAVE BRIDGE



ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

MOTOROLA TYPE NO.	DEVICE MARKING LETTER SYMBOLS	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) V_{RM} Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) V_{in} Volts	DC OUTPUT VOLTAGE Res. Load V_{out} Volts	DC OUTPUT VOLTAGE Cap. Load V_{out} Volts	DC OUTPUT CURRENT @ 75°C AMBIENT I_{out} Amp	PEAK FULL WAVE ONE CYCLE SURGE CURRENT NON-REPETITIVE (SINUSOIDAL 60 cps) $I_{FM(surge)}$ Amp	PEAK FULL WAVE REPETITIVE FORWARD CURRENT (NONSINUSOIDAL 60 cps) $I_{FM(rep)}$ Amp
MDA920-1	BA	25	18	15	25	1.0	32.0	5.0
-2	BB	50	35	30	50			
-3	BC	100	70	62	100			
-4	BD	200	140	124	200			
-5	BE	300	210	185	300			
-6	BF	400	280	250	400			
-7	BG	600	420	380	600			

MINIATURE DIODE ASSEMBLIES (continued)

FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS

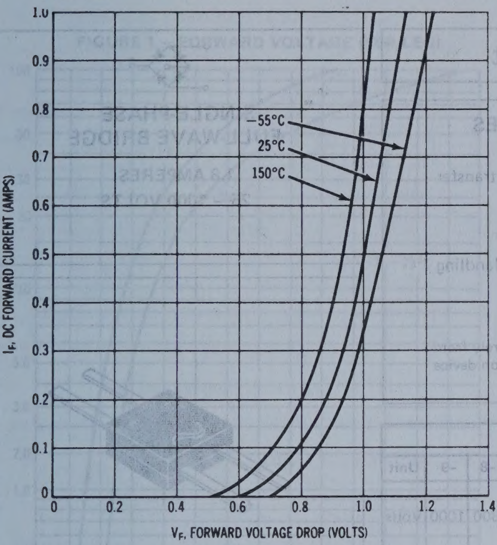


FIGURE 2 — TYPICAL REVERSE CHARACTERISTICS

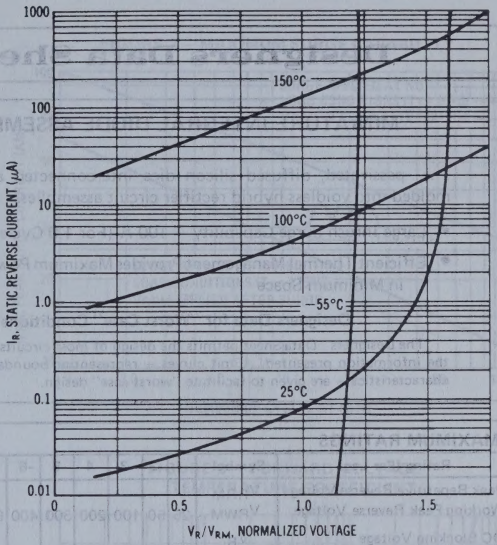


FIGURE 3 — MAX ALLOWABLE SURGE CURRENT

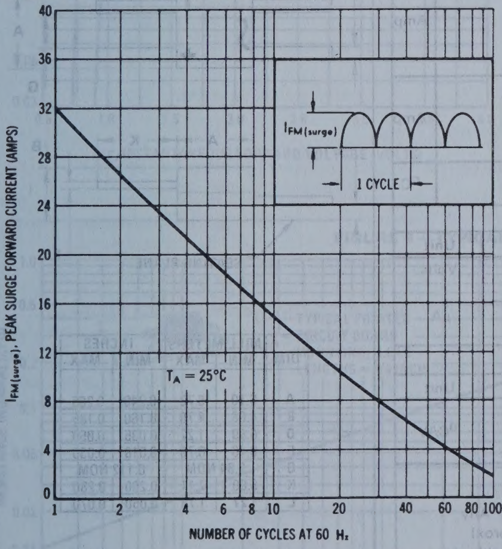
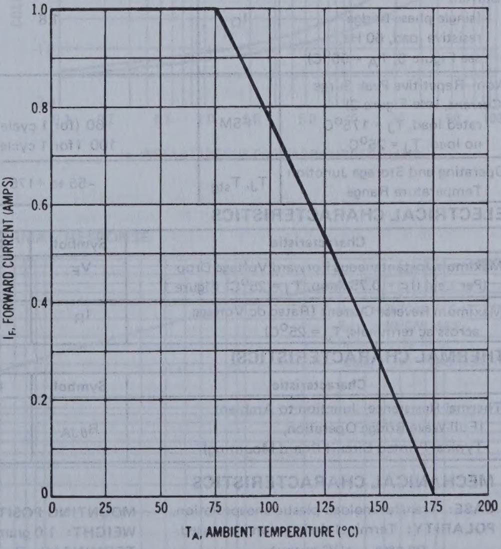


FIGURE 4 — MAX ALLOWABLE DC OUTPUT CURRENT



MDA922-1 (SILICON)
thru
MDA922-9

Designers Data Sheet

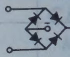
MINIATURE INTEGRAL DIODE ASSEMBLIES

. . . passivated, diffused-silicon dice interconnected and transfer molded into voidless hybrid rectifier circuit assemblies.

- Large Inrush Surge Capability – 100 A (For 1.0 Cycle)
- Efficient Thermal Management Provides Maximum Power Handling in Minimum Space

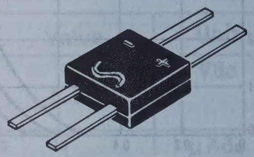
Designers Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.



SINGLE-PHASE FULL-WAVE BRIDGE

1.8 AMPERES
25 – 1000 VOLTS



MAXIMUM RATINGS

Rating (Per Leg)	Symbol	-1	-2	-3	-4	-5	-6	-7	-8	-9	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	25	50	100	200	300	400	600	800	1000	Volts
DC Output Voltage Resistive Load	Vdc	15	30	62	124	185	250	380	500	620	Volts
Capacitative Load	Vdc	25	50	100	200	300	400	600	800	1000	Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	18	35	70	140	210	280	420	560	700	Volts
Average Rectified Forward Current (single phase bridge resistive load, 60 Hz, see Figure 6, $T_A = 55^oC$)	I_O	1.8									Amp
Non–Repetitive Peak Surge Current, (see Figure 2) rated load, $T_J = 175^oC$ no load, $T_J = 25^oC$	I_{FSM}	60 (for 1 cycle) 100 (for 1 cycle)									Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +175									^oC

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop (Per Leg) ($I_F = 0.75$ Amp, $T_J = 25^oC$) Figure 1	V_F	1.1	Volts
Maximum Reverse Current (Rated dc Voltage across ac terminals, $T_J = 25^oC$)	I_R	20	μA

THERMAL CHARACTERISTICS)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Full-Wave Bridge Operation, Typical Printed Circuit Board Mounting)	$R_{\theta JA}$	40	$^oC/W$

MECHANICAL CHARACTERISTICS

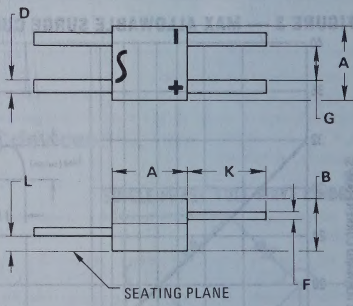
CASE: Transfer-molded plastic encapsulation.

POLARITY: Terminal-designation embossed on case
+DC output
-DC output
~AC input

MOUNTING POSITION: Any

WEIGHT: 1.0 gram (approx)

TERMINALS: Readily solderable connections, corrosion resistant.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.73	0.240	0.265
B	4.06	4.70	0.160	0.185
D	0.89	1.27	0.035	0.050
F	0.46	0.76	0.018	0.030
G	2.84 NOM		0.112 NOM	
K	6.60	7.11	0.260	0.280
L	1.27	1.78	0.050	0.070

CASE 216

FIGURE 1 – FORWARD VOLTAGE (PER LEG)

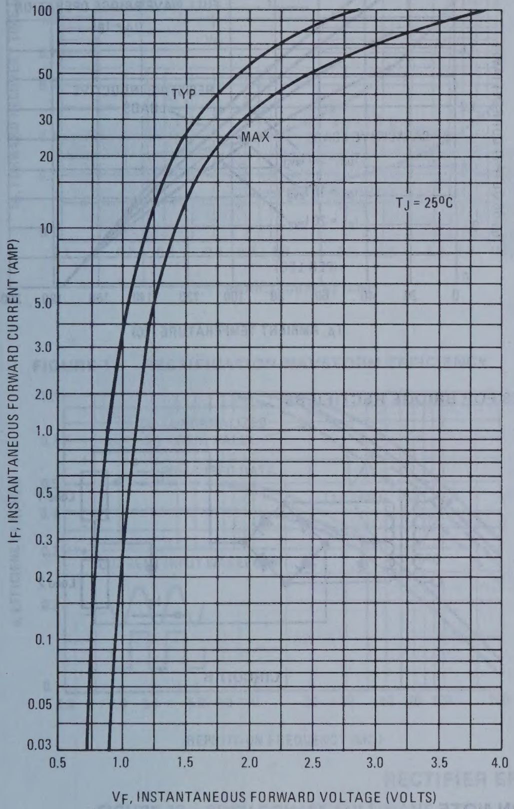


FIGURE 2 – MAXIMUM SURGE CAPABILITY

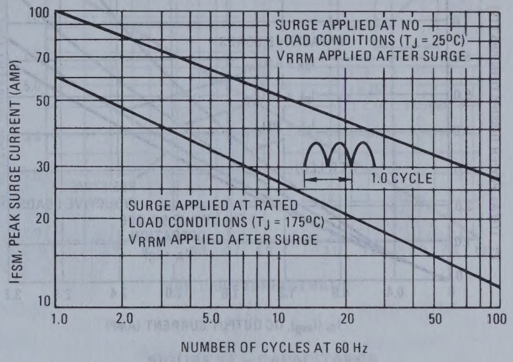


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

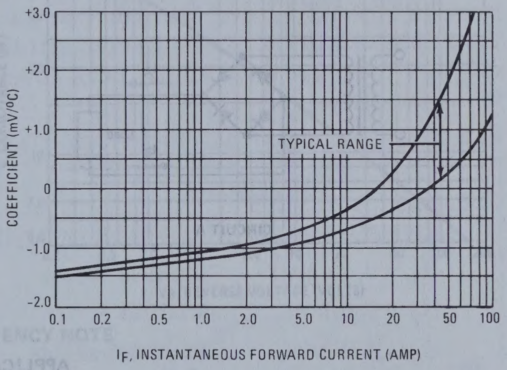


FIGURE 4 – TYPICAL THERMAL RESPONSE

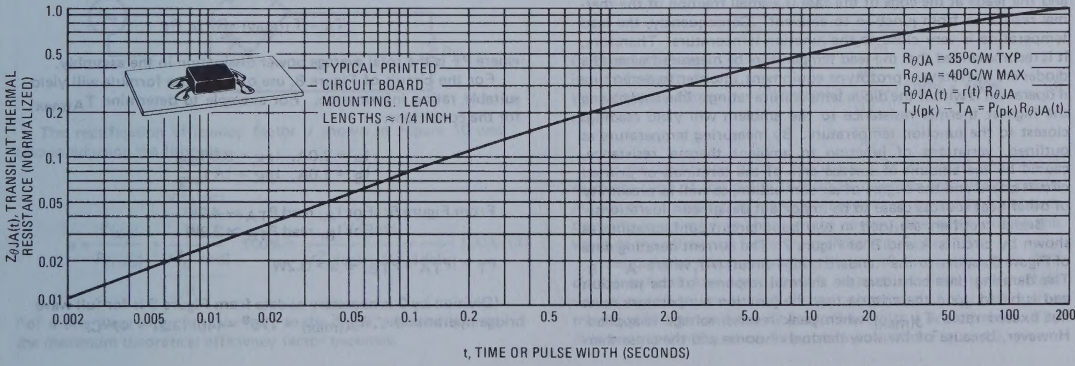


FIGURE 5 – POWER DISSIPATION

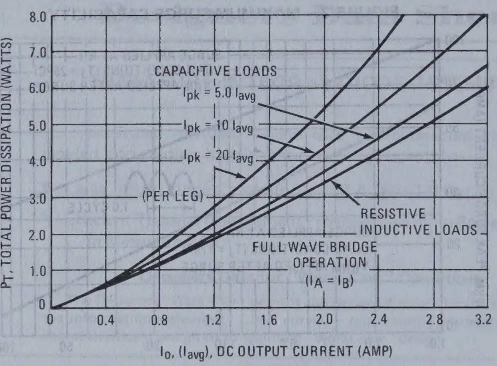


FIGURE 6 – CURRENT DERATING

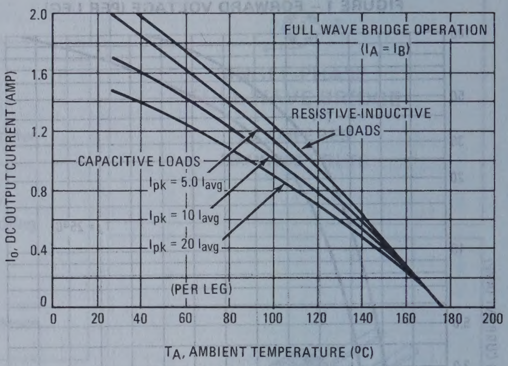
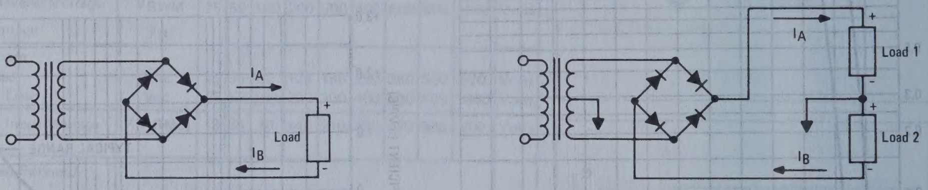


FIGURE 7 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



CIRCUIT A

CIRCUIT B

APPLICATION NOTE

The Data of Figure 4 applies for typical wire terminal or printed circuit board mounting conditions in still air. Under these or similar conditions, the thermal resistance between the diode junctions and the leads at the edge of the case is a small fraction of the thermal resistance from junction to ambient. Consequently, the lead temperature is very close to the junction temperature. Therefore, it is recommended that the lead temperature be measured when the diodes are operating in prototype equipment, in order to determine if operation is within the diode temperature ratings. The lead having the highest thermal resistance to the ambient will yield readings closest to the junction temperature. By measuring temperature as outlined, variations of junction to ambient thermal resistance, caused by the amount of surface area of the terminals or printed circuit board and the degree of air convection, as well as proximity of other heat sources cease to be important design considerations.

Bridge rectifiers are used in two basic circuit configurations as shown by circuits A and B of Figure 7. The current derating data of Figure 6 applies to the standard bridge circuit (A), where $I_A = I_B$. The derating data considers the thermal response of the junction and is based upon the criteria that the junction temperature must not exceed rated $T_{J(max)}$ when peak reverse voltage is applied. However, because of the slow thermal response and the close thermal coupling between the individual semiconductor die in the MDA922 assembly, the maximum ambient temperature is given closely by

$$T_A = T_{J(max)} - R_{\theta JA} P_T$$

where P_T is the total average power dissipation in the assembly.

For the circuit of Figure B, use of the above formula will yield suitable rating information. For example to determine $T_{A(max)}$ for the conditions:

$$I_A = 2.0\text{A},\ I_{PK} = 8.0\ I_{avg}$$
$$I_B = 1.0\text{A},\ I_{PK} = 18\ I_{avg}$$

From Figure 5: For I_A, read $P_{TA} \approx 4.2\text{W}$
For I_B, read $P_{TB} \approx 2.2\text{W}$

$$P_T = (P_{TA} + P_{TB}) \div 2 = 3.2\text{W}$$

(Division by 2 is necessary as data from Figure 5 is for full wave bridge operation.) $\therefore T_{A(max)} = 175^\circ - (40)(3.2) = 47^\circ\text{C}$.

TYPICAL DYNAMIC CHARACTERISTICS (PER LEG)

FIGURE 8 — FORWARD RECOVERY TIME

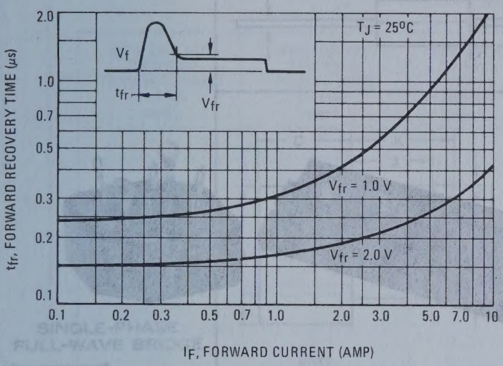


FIGURE 9 — REVERSE RECOVERY TIME

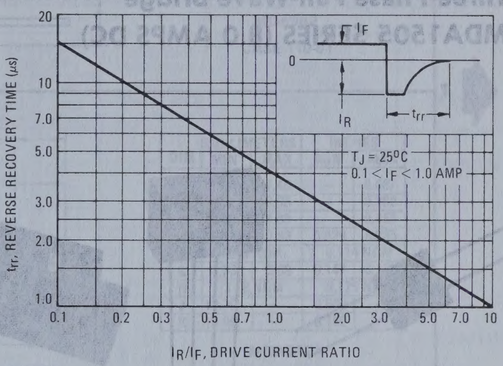


FIGURE 10 — RECTIFICATION WAVEFORM EFFICIENCY

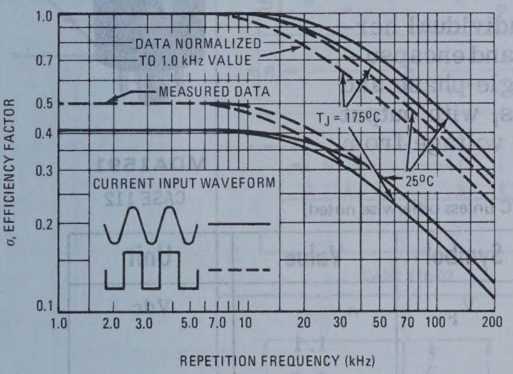
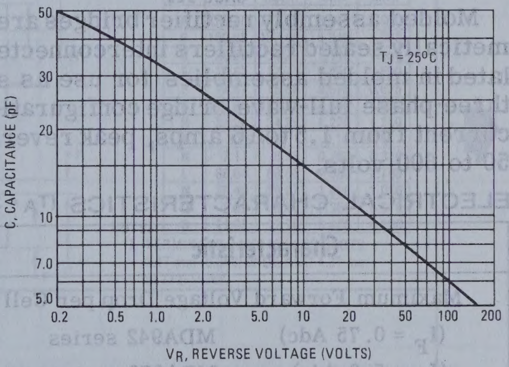
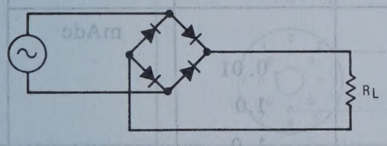


FIGURE 11 — CAPACITANCE



RECTIFIER EFFICIENCY NOTE

FIGURE 12 — SINGLE-PHASE FULL-WAVE BRIDGE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 10 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\frac{V^2{}_{o(dc)}}{R_L}}{\frac{V^2{}_{o(rms)}}{R_L}} \cdot 100\% = \frac{V^2{}_{o(dc)}}{V^2{}_{o(ac)} + V^2{}_{o(dc)}} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\frac{4V^2{}_m}{\pi^2 R_L}}{\frac{V^2{}_m}{2R_L}} \cdot 100\% = \frac{8}{\pi^2} \cdot 100\% = 81.2\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\frac{V^2{}_m}{R_L}}{\frac{V^2{}_m}{R_L}} \cdot 100\% = 100\% \quad (3)$$

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 9) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 10.

It should be emphasized that Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.

SILICON
MOLDED ASSEMBLY RECTIFIER BRIDGES

Single-Phase Full-Wave Bridge

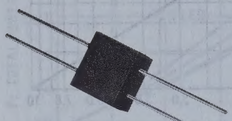
MDA942 SERIES (1.5 AMPS DC)

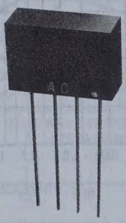
MDA972 SERIES (16.0 AMPS DC)

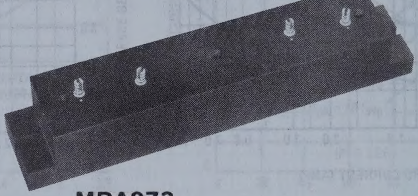
MDA1591 SERIES (4.0 AMPS DC)

Three-Phase Full-Wave Bridge

MDA1505 SERIES (8.0 AMPS DC)


MDA942
CASE 110


MDA942A
CASE 111


MDA972
CASE 116

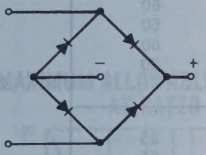
Molded assembly rectifier bridges are individual hermetically sealed rectifiers interconnected and encapsulated in molded assemblies for use as single-phase and three-phase full-wave bridge configurations, with output current from 1.5 to 16 amps, peak reverse voltage from 50 to 600 volts.

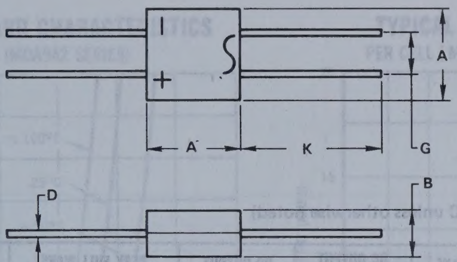
MDA1591
CASE 112

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Value	Unit
Maximum Forward Voltage Drop per Cell		V_F		Vdc
(I_F = 0.75 Adc)	MDA942 series		1.1	
(I_F = 5.0 Adc)	MDA972 series		1.0	
(I_F = 4.0 Adc)	MDA1505 series		1.0	
(I_F = 2.0 Adc)	MDA1591 series		1.0	
Maximum Reverse Current per Cell		I_R		mAdc
(V_R = Rated V_{RM})	MDA942 series		0.01	
	MDA972 series		1.0	
	MDA1505 series		1.0	
	MDA1591 series		1.0	

SINGLE-PHASE FULL-WAVE BRIDGE



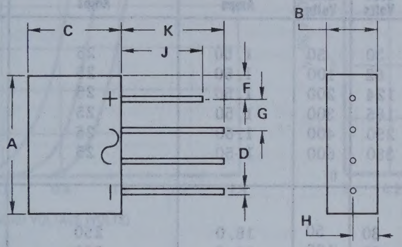


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	14.35	–	0.565
B	–	7.24	–	0.285
D	0.76	0.86	0.030	0.034
G	6.22	6.48	0.245	0.255
K	–	27.94	–	1.100

MDA942

CASE 110-01

1

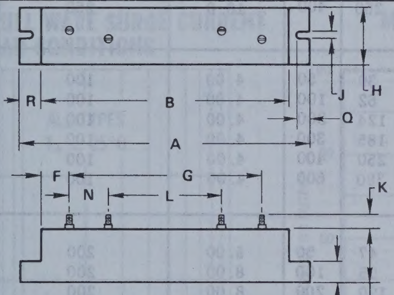


NOTE:
1. POLARITY INK MARKED ON CASE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	17.45	–	0.687
B	–	6.60	–	0.260
C	–	11.89	–	0.468
D	0.74	0.89	0.029	0.035
F	2.90 NOM		0.114 NOM	
G	3.73	3.89	0.147	0.153
H	3.18 NOM		0.125 NOM	
J	12.70	–	0.500	–
K	19.05	–	0.750	–

MDA942A

CASE 111-01

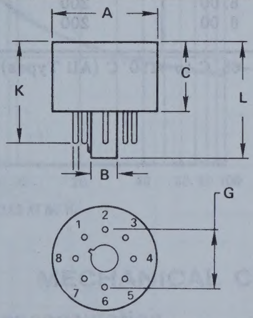


CASE 116-02

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	176.28	177.80	6.940	7.000
B	150.88	152.40	5.940	6.000
C	28.96	34.29	1.140	1.350
E	10.67	12.70	0.420	0.500
F	14.61	15.88	0.575	0.625
G	116.84	121.92	4.600	4.800
H	32.26	34.29	1.270	1.350
J	3.66 NOM		0.144 NOM	
K	7.11	8.13	0.280	0.320
L	66.04	68.58	2.600	2.700
N	25.40	26.67	1.000	1.050
Q	8.89	9.40	0.350	0.370
R	11.68	12.70	0.460	0.500

NOTES:
1. TERMINALS HAVE MILLED SLOTS 1.17 mm (0.046) WIDE AND 4.37 mm (0.172) DEEP.

2



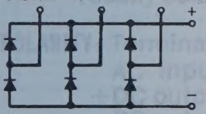
STYLE 1:
PIN 1. +
2. OPEN
3. AC
4. OPEN
5. –
6. OPEN
7. AC
8. OPEN
COLOR CODED

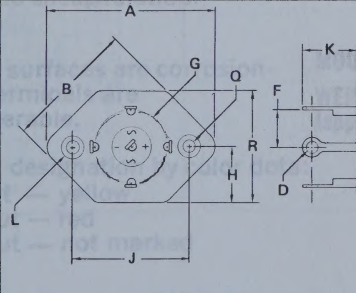
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	32.13	–	1.265
B	7.75	8.00	0.305	0.315
C	20.32	21.72	0.800	0.855
G	17.32	17.58	0.682	0.692
K	31.27	32.89	1.231	1.295
L	34.24	35.31	1.348	1.390

CASE 112-03

3

THREE-PHASE FULL-WAVE BRIDGE





CASE 114-01

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	57.66	–	2.270
B	43.18	44.45	1.700	1.750
C	21.08	22.10	0.830	0.870
D	3.56	–	0.140	–
F	13.84	14.48	0.545	0.570
G	28.58 BSC		1.125 BSC	
H	–	22.10	–	0.870
J	43.94 BSC		1.730 BSC	
K	5.08	–	0.200	–
L	6.22	6.48	0.245	0.255
Q	3.30	3.81	0.130	0.150
R	–	44.20	–	1.740

NOTES:
1. DIM "L" IS 3.18 mm (0.125) DEEP;
DIM "Q" IS THRU HOLE

4

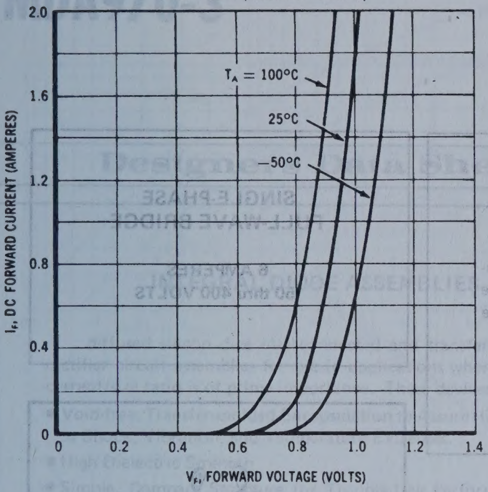
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

	TYPE NO.	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) Volts	DC OUTPUT VOLTAGE		DC OUTPUT CURRENT @ 55°C AMBIENT Amps	PEAK FULL WAVE ONE CYCLE SURGE CURRENT (60 Hz) Amps	PEAK FULL WAVE RECURRENT FORWARD CURRENT (60 Hz) Amps
				Res. Load Volts	Cap. Load Volts			
1	MDA942-1	50	35	30	50	1.50	25	6.0
	-2	100	70	62	100	1.50	25	6.0
	-3	200	140	124	200	1.50	25	6.0
	-4	300	210	185	300	1.50	25	6.0
	-5	400	280	250	400	1.50	25	6.0
	-6	600	420	380	600	1.50	25	6.0
2	MDA972-1	50	35	30	50	16.0	250	60
	-2	100	70	62	100	16.0	250	60
	-3	200	140	124	200	16.0	250	60
	-4	300	210	185	300	16.0	250	60
	-5	400	280	250	400	16.0	250	60
3	MDA1591 -1	50	35	30	50	4.00	100	25
	-2	100	70	62	100	4.00	100	25
	-3	200	140	124	200	4.00	100	25
	-4	300	210	185	300	4.00	100	25
	-5	400	280	250	400	4.00	100	25
	-6	600	420	380	600	4.00	100	25
4	MDA1505 -1	50	35	47	50	8.00	200	45
	-2	100	70	95	100	8.00	200	45
	-3	200	140	190	200	8.00	200	45
	-4	300	210	285	300	8.00	200	45
	-5	400	280	380	400	8.00	200	45
	-6	600	420	570	600	8.00	200	45

Maximum Operating and Storage Temperature: -65°C to +150°C (All Types)

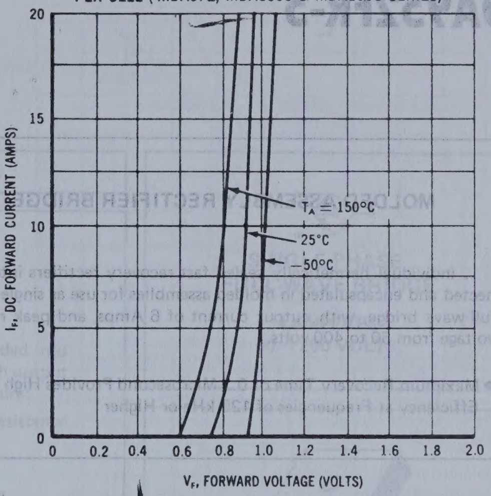
TYPICAL FORWARD CHARACTERISTICS

PER CELL (MDA942 SERIES)

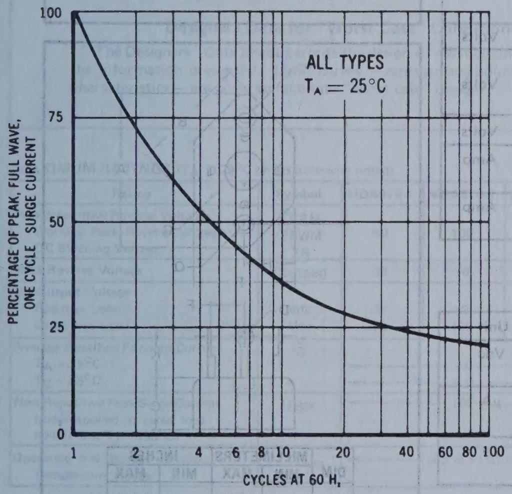


TYPICAL FORWARD CHARACTERISTICS

PER CELL (MDA972, MDA1505 & MDA1591 SERIES)

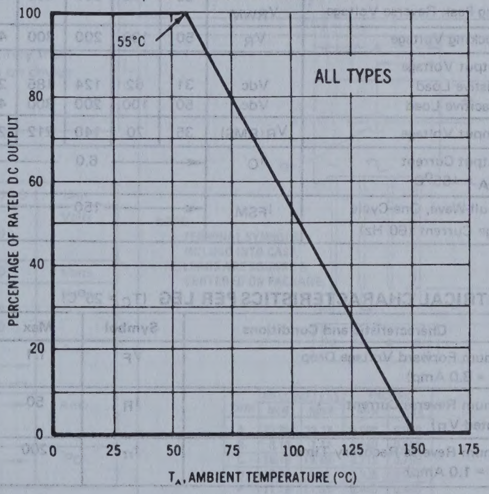


MAXIMUM ALLOWABLE FULL WAVE SURGE CURRENT AT RATED LOAD CONDITIONS



MAXIMUM ALLOWABLE DC OUTPUT

(RESISTIVE OR INDUCTIVE LOAD)



MECHANICAL CHARACTERISTICS

CASE: Molded plastic encapsulation.

FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Terminal designation by color dots:
AC input — yellow
+DC output — red
−DC output — not marked

MOUNTING POSITION: Any

WEIGHT: (approx.)
MDA942, MDA942A — 3.8 grams
MDA972 — 340 grams
MDA1591 — 39 grams

MDA952FR-1
thru
MDA952FR-5

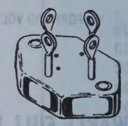
MOLDED ASSEMBLY RECTIFIER BRIDGE

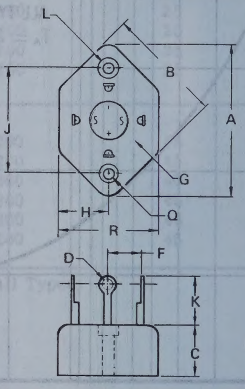
. . . individual hermetically sealed fast recovery rectifiers interconnected and encapsulated in molded assemblies for use as single-phase full-wave bridge, with output current of 6 Amps, and peak reverse voltage from 50 to 400 volts.

- Maximum Recovery Time of 0.2 Microsecond Provides High Efficiency at Frequencies of 125 kHz or Higher

SINGLE-PHASE FULL-WAVE BRIDGE

6 AMPERES
50 thru 400 VOLTS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	47.88	–	1.885
B	36.32	36.83	1.430	1.450
C	15.88	16.51	0.625	0.650
D	3.56	–	0.140	–
F	9.53	10.80	0.375	0.425
G	20.65 BSC		0.813 BSC	
H	15.88	16.26	0.625	0.640
J	33.32 BSC		1.312 BSC	
K	6.35	–	0.250	–
L	6.22	6.48	0.245	0.255
Q	3.30	3.81	0.130	0.150
R	31.75	32.51	1.250	1.280

NOTES:
1. DIM "L" IS 3.18 mm (0.125) DEEP; DIM "Q" IS THRU HOLE.

CASE 113-01

MAXIMUM RATINGS

Rating (Per Leg)	Symbol	MDA952FR					Unit
		-1	-2	-3	-4	-5	
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage	V_{RRM} V_{RWM}	50	100	200	300	400	Volts
DC Blocking Voltage	V_R	50	100	200	300	400	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 31 50	 62 100	 124 200	 185 300	 250 400	Volts
RMS Input Voltage	$V_{R(RMS)}$	35	70	140	212	282	Volts
DC Output Current @ $T_A = +55^{\circ}C$	I_O	← 6.0 →					Amp
Peak Full-Wave, One-Cycle Surge Current (60 Hz)	I_{FSM}	← 150 →					Amp

ELECTRICAL CHARACTERISTICS PER LEG ($T_C = 25^{\circ}C$)

Characteristic and Conditions	Symbol	Max	Unit
Maximum Forward Voltage Drop (I_F = 3.0 Amp)	V_F	1.1	Vdc
Maximum Reverse Current (Rated V_R)	I_R	50	μA
Maximum Reverse Recovery Time (I_F = 1.0 Amp)	t_{rr}	200	ns

MECHANICAL CHARACTERISTICS

CASE: Molded plastic encapsulation, hermetically sealed individual rectifier cells.

FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked

MOUNTING POSITION: Any

WEIGHT: 35 grams (approx.)

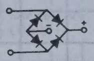
MDA970-1
thru
MDA970-3

Designers Data Sheet

INTEGRAL DIODE ASSEMBLIES

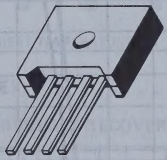
. . . diffused silicon dice interconnected and transfer molded into rectifier circuit assemblies for use in applications where high output current/size ratio is of prime importance. These devices feature:

- Void-free, Transfer-molded Encapsulation to Assure High Resistance to Shock, Vibration, and Temperature Extremes
- High Dielectric Strength
- Simple, Compact Structure for Trouble-free Performance
- High Surge Capability — 100 Amps



SINGLE-PHASE
FULL-WAVE BRIDGE

4 AMPERES
50 – 200 VOLTS



Designers Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

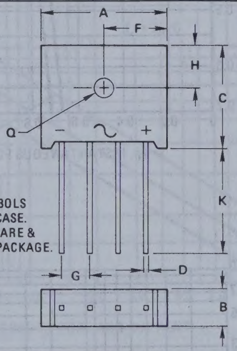
Rating	Symbol	MDA970-1	MDA970-2	MDA970-3	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	Volts
DC Output Voltage					Volts
Resistive Load	Vdc	31	62	124	
Capacitive Load	Vdc	50	100	200	
Average Rectified Forward Current	I_O				Amp
T_A = 25°C		4.0			
T_C = 55°C		8.0			
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, T_J = 150°C)	I_{FSM}	100			Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS

Characteristics		Symbol	Max (Per Die)	Unit
Thermal Resistance, Junction to Case	Each Die	$R_{\theta JC}$	10	°C/W
	Effective Bridge	$R_{\theta(EFF)}$	7.75	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Instantaneous Forward Voltage (Per Diode)	v_F	–		Vdc
(i_F = 6.28 Amp, T_J = 25°C)		–	0.9	
(i_F = 6.28 Amp, T_J = 150°C)		–	0.8	
Reverse Current (Rated V_{RM} applied to ac terminals, + and – terminals open, T_A = 25°C)	I_R	–	1.0	mA



NOTE:
1. TERMINAL SYMBOLS MOLDED INTO CASE.
2. LEADS ARE SQUARE & CENTERED ON PACKAGE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	22.35	23.37	0.880	0.920
B	6.10	7.11	0.240	0.280
C	18.16	19.18	0.715	0.755
D	0.89	1.14	0.035	0.045
F	11.18	11.68	0.440	0.460
G	4.57	5.59	0.180	0.220
H	7.24	7.75	0.285	0.305
K	19.05	–	0.750	–
Q	3.43	3.94	0.135	0.155

CASE 117

CASE: Transfer-molded plastic encapsulation.

FINISH: All external surfaces are corrosion-resistant. Leads are readily solderable.

POLARITY: Embossed symbols
AC input = ~
DC output = +
DC output = -

MOUNTING POSITION: Any

WEIGHT (Approximately): 7.5 Grams

MOUNTING TORQUE: 5 in.-lb Max

FIGURE 1 – FORWARD VOLTAGE

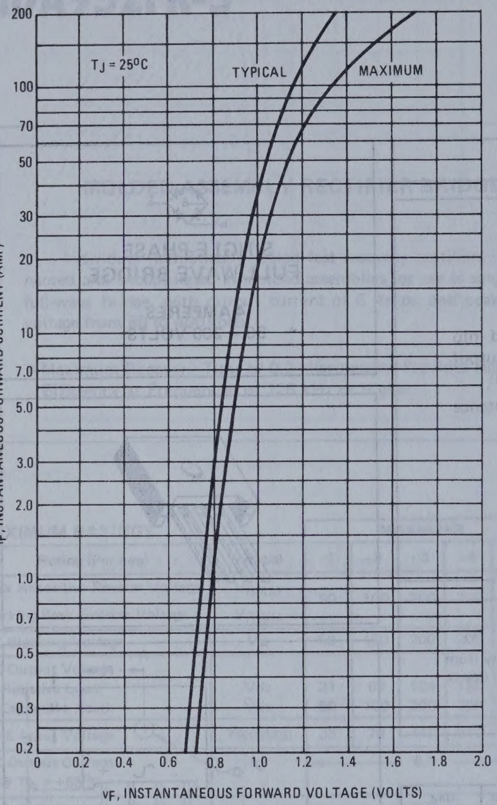


FIGURE 2 – MAXIMUM SURGE CAPABILITY

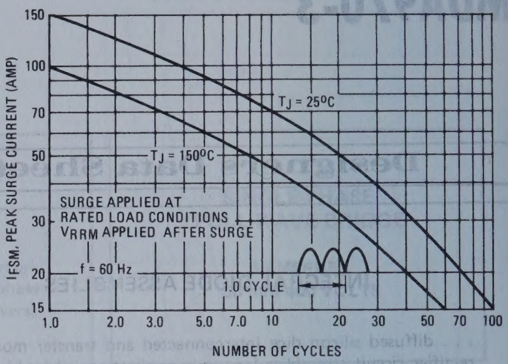


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

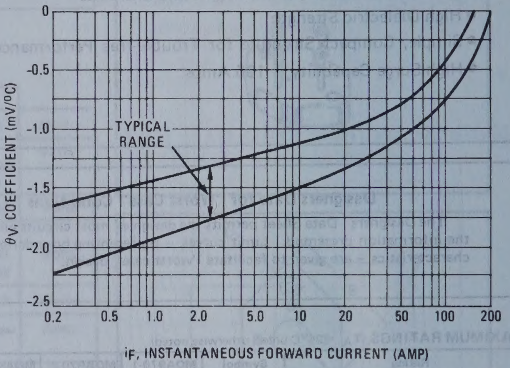
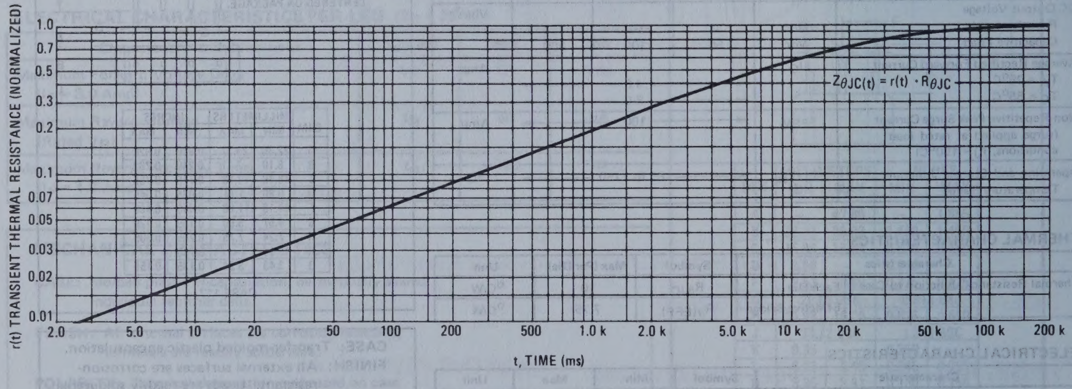


FIGURE 4 – TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – CASE TEMPERATURE DERATING

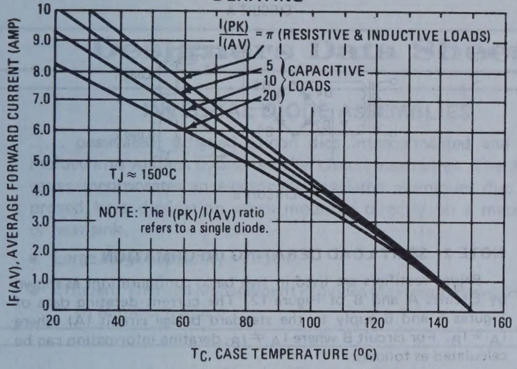
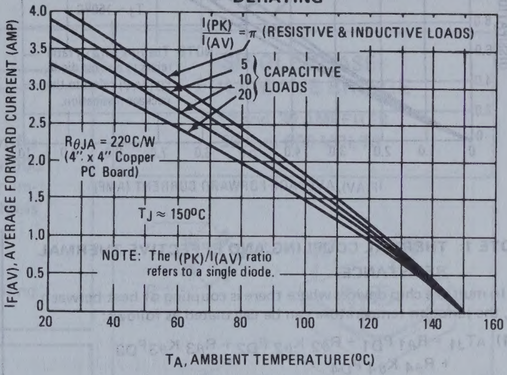


FIGURE 6 – AMBIENT TEMPERATURE DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 – RECTIFICATION EFFICIENCY

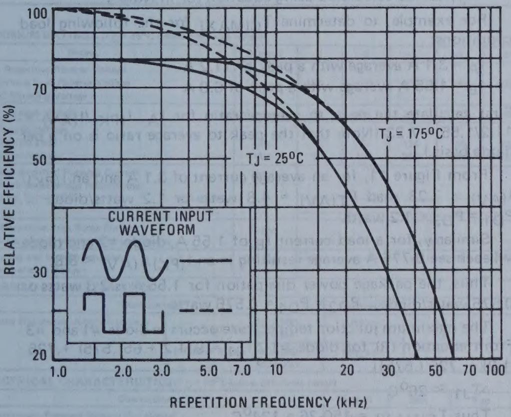


FIGURE 8 – REVERSE RECOVERY TIME

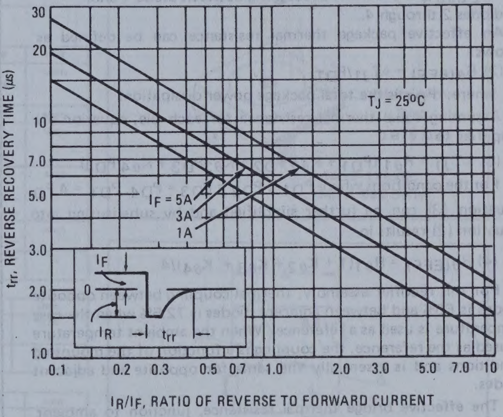


FIGURE 9 – JUNCTION CAPACITANCE

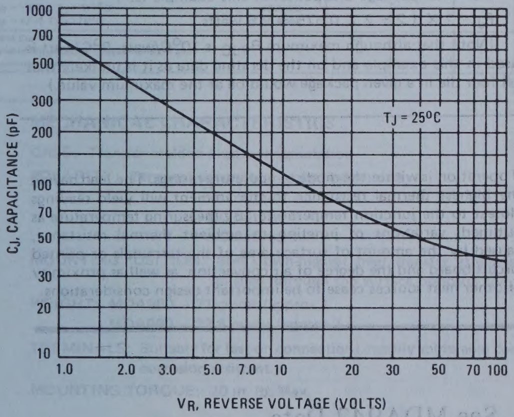


FIGURE 10 – FORWARD RECOVERY TIME

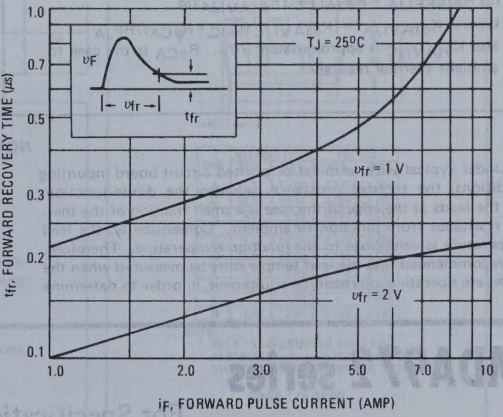


FIGURE 11 – POWER DISSIPATION

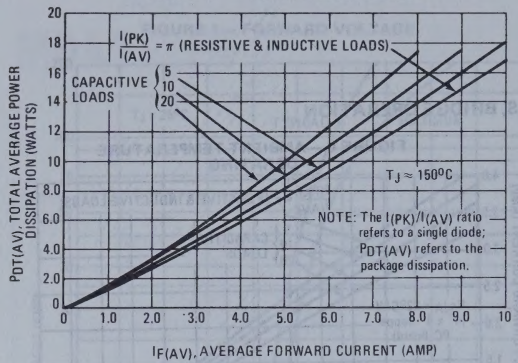
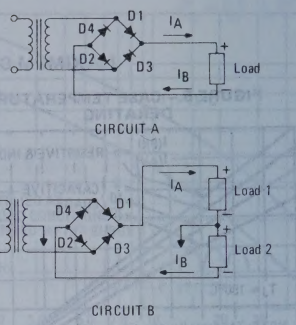


FIGURE 12 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



NOTE 1: THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1
$R_{\theta 1}$ thru 4 is the thermal resistance of diodes 1 through 4
P_{D1} thru 4 is the power dissipated in diodes 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\,P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

For this rectifier assembly, thermal coupling between opposite diodes is 65% and between adjacent diodes is 72.5% when the case temperature is used as a reference. When the ambient temperature is used as the reference, the coupling is a function of the mounting conditions and is essentially the same for opposite and adjacent diodes.

The effective bridge thermal resistance, junction to ambient, is (from equation 4).

(5) $R_{\theta(EFF)JA} = R_{\theta JA}(1 + 3K_{\theta(AV)JA})/4$

Where: $K_{\theta(AV)JA} \approx (K_{\theta(AV)JC} R_{\theta JC} + R_{\theta CA})/R_{\theta JA}$
and $K_{\theta(AV)JC}$ is approximately 70%. $R_{\theta CA}$ is the case to ambient thermal resistance.

NOTE 2: SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown by circuits A and B of Figure 12. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

(6) $T_{R(MAX)} = T_{J(MAX)} - \Delta T_{J1}$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the following load conditions:

I_A = 3.1 A average with a peak of 11.2 A
I_B = 1.55 A average with a peak of 6.8 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 11.2/1.55 = 7.23 (Note that the peak to average ratio is on a per diode basis.)

From Figure 11, for an average current of 3.1 A and an $I_{(PK)}/I_{(AV)}$ = 7.23 read $P_{T(AV)}$ = 4.8 watts or 1.2 watts/diode ∴ $P_{D1} = P_{D3}$ = 1.2 watts.

Similarly, for a load current I_B of 1.55 A, diode #2 and diode #4 each see 0.775 A average resulting in an $I_{(PK)}/I_{(AV)} \approx 8.8$.

Thus, the package power dissipation for 1.55 A is 2.3 watts or 0.575 watts/diode ∴ $P_{D2} = P_{D4}$ = 0.575 watts.

The maximum junction temperature occurs in diode #1 and #3. From equation (3) for diode #1 ΔT_{J1} = 9[1.2 + .65(.575) + .725 (1.2) + .725 (.575)]

$\Delta T_{J1} \approx 26°C$

Thus $T_{C(MAX)}$ = 150-26 = 124°C

The total package dissipation in this example is:

$P_J = 2 \times 1.2 + 2 \times 0.575 \approx 3.6$ watts

(Note that although maximum $R_{\theta JC}$ is 10°C/watt, 9°C/watt is used in this example and on the derating data as it is unlikely that all four die in a given package would be at the maximum value.)

NOTE 3

Under typical wire terminal or printed circuit board mounting conditions, the thermal resistance between the diode junctions and the leads at the edge of the case is a small fraction of the thermal resistance from junction to ambient. Consequently, the lead temperature is very close to the junction temperature. Therefore, it is recommended that the lead temperature be measured when the diodes are operating in prototype equipment, in order to determine if operation is within the diode temperature ratings. The lead having the highest thermal resistance to the ambient will yield readings closest to the junction temperature. By measuring temperature as outlined, variations of junction to ambient thermal resistance, caused by the amount of surface area of the terminals or printed circuit board and the degree of air convection, as well as proximity of other heat sources cease to be important design considerations.

MDA972 series

For Specifications, See MDA942 Data.

MDA980-1 thru MDA980-6
MDA990-1 thru MDA990-6

Designers Data Sheet

INTEGRAL DIODE ASSEMBLIES

. . . passivated, diffused silicon dice interconnected and transfer molded into voidless hybrid rectifier circuit assemblies. The MDA990 series incorporates an electrically insulated aluminum disc for improved heat dissipation when mounted directly on a metal chasis or heat sink.

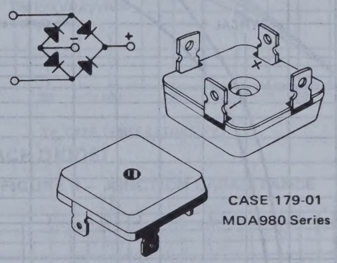
- Large surge capability — 300 A
- Efficient Thermal Management Provides Maximum Power Handling In Minimum Space

Designers Data for "Worst Case" Conditions

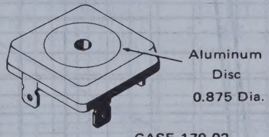
The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

SINGLE-PHASE FULL-WAVE BRIDGE

12 and 30 AMPERES
50 thru 600 VOLTS



CASE 179-01
MDA980 Series



CASE 179-02
MDA 990 Series

MAXIMUM RATINGS ($T_C = 25^{\circ}C$ unless otherwise noted)

Rating	Symbol	-1	-2	-3	-4	-5	-6	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
DC Output Voltage								Volts
Resistive Load	Vdc	30	62	124	185	250	380	
Capacitive Load	Vdc	50	100	200	300	400	600	
Average Rectified Forward Current (Single phase bridge resistive load, 60 Hz, $T_C = 55^{\circ}C$) MDA980	I_O	← 12 →						Amp
MDA990		← 30 →						
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 300 →						Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →						°C

THERMAL CHARACTERISTICS

Characteristic			Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	Each Die	MDA980	$R_{\theta JC}$	8.5	11	°C/W
		MDA990		4.5	6.0	
	Effective Bridge	MDA980	$R_{\theta(EFF)}$	–	6.05	°C/W
		MDA990		–	2.28	

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode)		v_F				Volts
($i_F = 18.9$ A)	MDA980		–	0.88	0.97	
($i_F = 47$ A)	MDA990		–	0.98	1.07	
($i_F = 18.9$ A, $T_J = 175^{\circ}C$)	MDA980		–	–	0.85	
($i_F = 47$ A, $T_J = 175^{\circ}C$)	MDA990		–	–	0.98	
Reverse Current (Rated V_{RM} applied to ac terminals, + and – terminals open)		I_R	–	–	0.5	mA

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic encapsulation

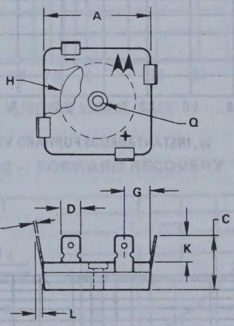
POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked

MOUNTING POSITION: Bolt down-highest heat transfer efficiency accomplished through the surface opposite the terminals.

WEIGHT: MDA980 — 21 grams (approx.)
MDA990 — 22.5 grams (approx.)

TERMINALS: Suitable for fast-on connections, readily solderable connections, corrosion resistant.

MOUNTING TORQUE: 20 in. lb. Max.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	31.37	31.88	1.235	1.255
C	16.76	19.30	0.660	0.760
D	6.22	6.48	0.245	0.255
F	0.74	0.86	0.029	0.034
G	8.64	10.16	0.340	0.400
H	21.82	23.62	0.859	0.930
J	2.16	2.54	0.085	0.100
K	7.49	9.52	0.295	0.375
L	–	1.90	–	0.075
Q	3.56	3.94	0.140	0.155

NOTE:
1. HOLE "Q" IS COUNTER SUNK FOR #6 SCREW, 7.37 mm (0.290) MAXIMUM DIA., 1.52/2.79 mm (0.060/0.110) DEEP.

CASE 179-01-02

FIGURE 1 – FORWARD VOLTAGE

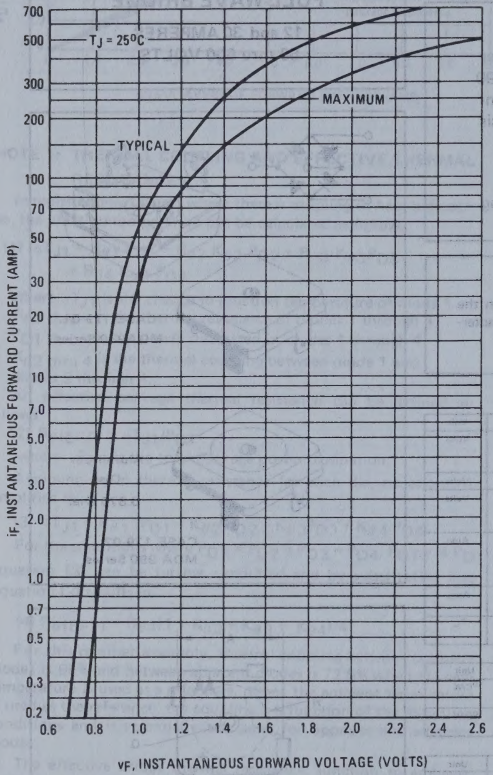


FIGURE 2 – MAXIMUM SURGE CAPABILITY

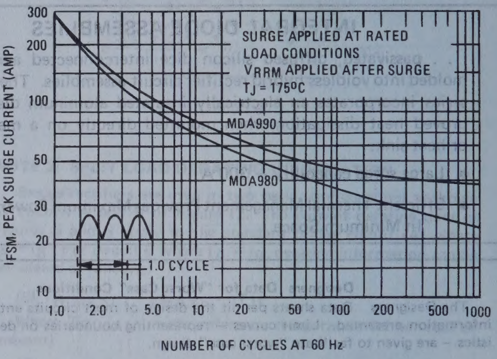


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

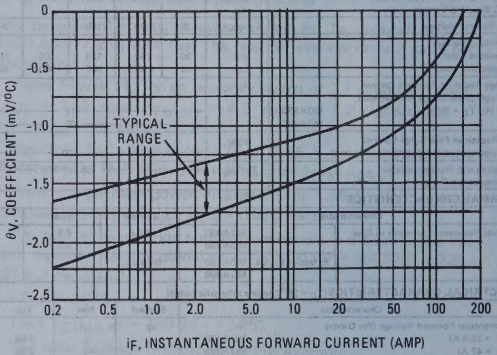
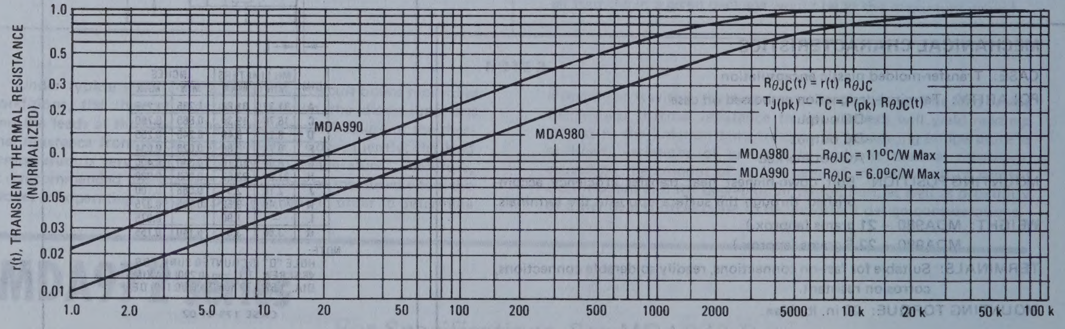


FIGURE 4 – TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – MDA980 CURRENT DERATING

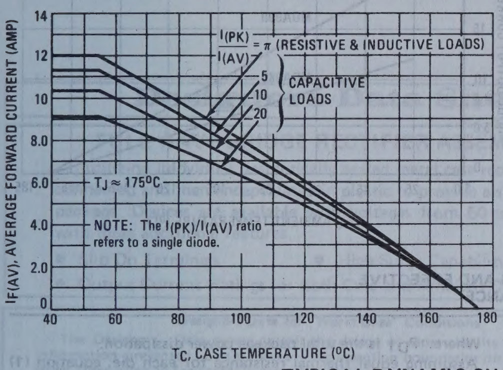
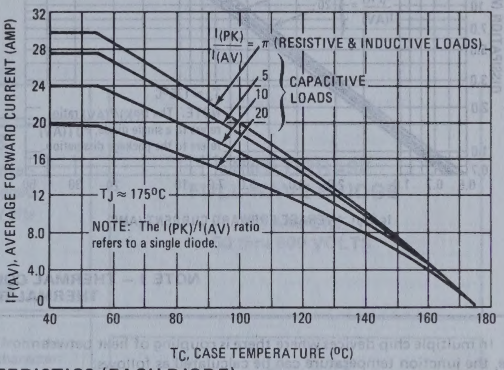


FIGURE 6 – MDA990 CURRENT DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 — RECTIFICATION EFFICIENCY

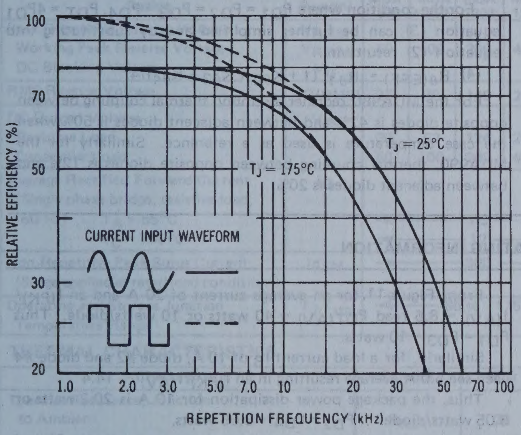


FIGURE 8 – JUNCTION CAPACITANCE

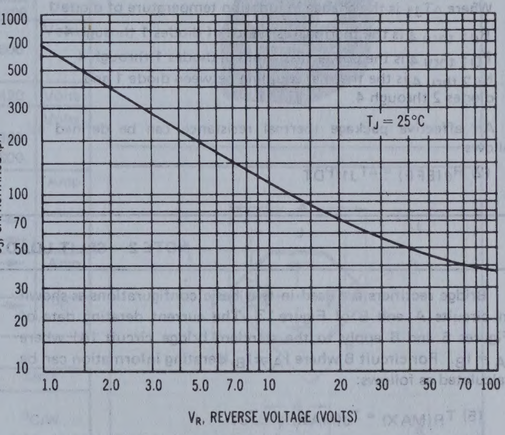


FIGURE 9 — REVERSE RECOVERY TIME

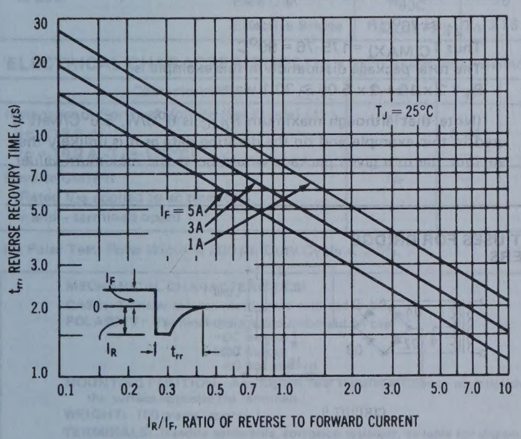


FIGURE 10 – FORWARD RECOVERY TIME

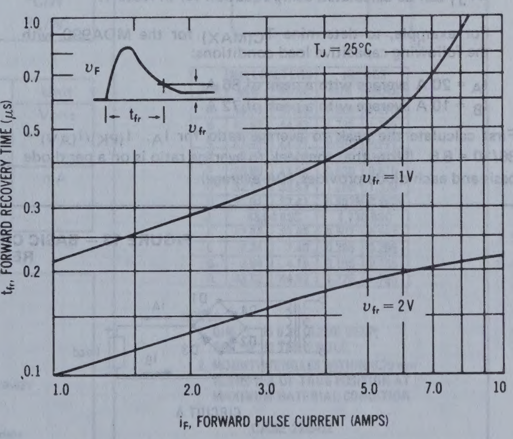


FIGURE 11 – POWER DISSIPATION

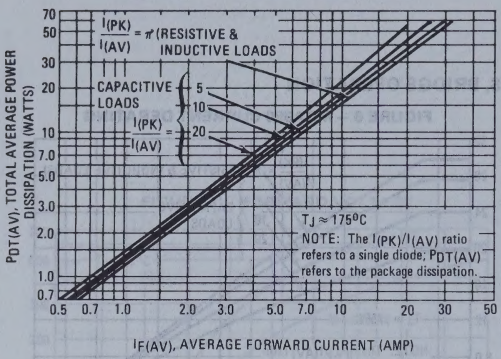
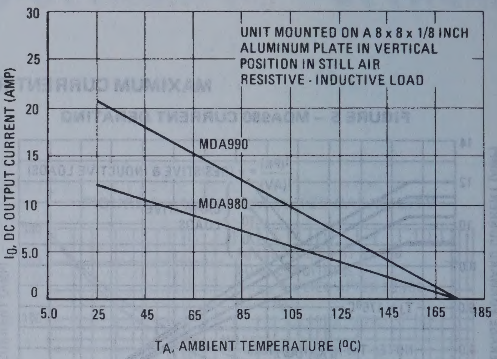


FIGURE 12 – CURRENT VERSUS AMBIENT TEMPERATURE



NOTE 1 – THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D2} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1

$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of diodes 1 through 4.

$P_{D1 \text{ thru } 4}$ is the power dissipated in diodes 1 through 4

$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the condition where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_{D1}$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}\ (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

For the MDA980 rectifier assembly, thermal coupling between opposite diodes is 42% and between adjacent diodes is 50% when the case temperature is used as a reference. Similarly for the MDA990, thermal coupling between opposite diodes is 12% and between adjacent diodes is 20%.

NOTE 2 – SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown in circuits A and B of Figure 13. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

(5) $T_{R(MAX)} = T_{J(MAX)} - \Delta T_{J1}$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the MDA990 with the following capacitive load conditions:

I_A = 20 A average with a peak of 86 A
I_B = 10 A average with a peak of 72 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 86/10 = 8.6. (Note that the peak to average ratio is on a per diode basis and each diode provides 10A average).

From Figure 11, for an average current of 20 A and an $I_{(PK)}/I_{(AV)}$ = 8.6 read $P_{DT(AV)}$ = 40 watts or 10 watts/diode. Thus $P_{D1} = P_{D3}$ = 10 watts.

Similarly, for a load current I_B of 10 A, diode #2 and diode #4 each see 5.0 A average resulting in an $I_{(PK)}/I_{(AV)} \approx 14.4$

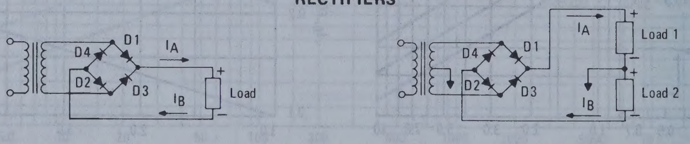
Thus, the package power dissipation for 10 A is 20.2 watts or 5.05 watts/diode. .: $P_{D2} = P_{D4}$ = 5.05 watts.

The maximum junction temperature occurs in diodes #1 and #3. From equation (3) for diode #1 ΔT_{J1} = 5.6 [10 + 0.12 (5.05) + 0.2 (10) + 0.2 (5.05)].

$\Delta T_{J1} \approx 76^\circ C$
Thus $T_{C(MAX)}$ = 175-76 = 99°C
The total package dissipation in this example is:
$P_J = 2 \times 10 + 2 \times 5.05 \approx 30.1$ watts

(Note that although maximum $R_{\theta JC}$ is 6°C/W, 5.6°C/watt is used in this example and on the derating data as it is unlikely that all four die in a given package would be at the maximum value).

FIGURE 13 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



CIRCUIT A

CIRCUIT B

MDA1200, MDA1201
MDA1202, MDA1204
MDA1206

Designers Data Sheet

FULL WAVE BRIDGE RECTIFIER ASSEMBLIES

. . . utilizing inidvidual hermetically sealed metal case rectifiers interconnected and then encapsulated in plastic to provide a single rugged package. Devices are available with voltages from 50 to 600 Volts with these additional features.

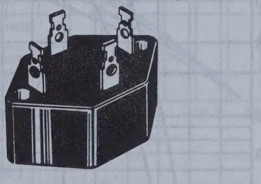
- Slip On Terminals
- High Surge Capability
- Output Current Ratings for Both Case and Ambient Conditions

Designers Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

SINGLE-PHASE FULL-WAVE BRIDGE

12 AMPERE
50 thru 600 VOLTS



MAXIMUM RATINGS ($T_C = 25^oC$ unless otherwise noted.)

Rating	Symbol	MDA 1200	MDA 1201	MDA 1202	MDA 1204	MDA 1206	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
DC Output Voltage	V_{dc}						Volts
Resistive Load		30	62	124	250	380	
Capacitive Load		50	100	200	400	600	
Average Rectified Forward Current (Single phase bridge, resistive load, 60 Hz)	I_O						Amp
$T_A = 55^oC$		← 4.5 →					
$T_C = 100^oC$		← 12 →					
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 300 →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →					^oC

THERMAL CHARACTERISTICS

Characteristic		Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	Each Die	$R_{\theta JA}$	28	$^oC/W$
	Effective Bridge	$R_{\theta JA(EFF)}$	17.15	$^oC/W$
Thermal Resistance, Junction to Case	Each Die	$R_{\theta JC}$	10	$^oC/W$
	Effective Bridge	$R_{\theta JC(EFF)}$	3.75	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Typ	Max	Unit
Instananeous Forward Voltage (Per Diode) (1)	v_F			Volts
($i_F = 18.9$ A)		0.94	1.05	
($i_F = 18.9$ A, $T_J = 175^oC$)		–	0.9	
Reverse Current (Rated V_R applied to ac terminals, + and – terminals open)	I_R	–	0.5	mA

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.

MECHANICAL CHARACTERISTICS

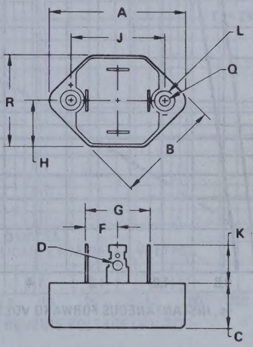
CASE: Transfer-molded plastic case with epoxy fill.

POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked

MOUNTING POSITION: Any, highest heat transfer efficiency accomplished through the surface opposite the terminals.

WEIGHT: 100 grams (approx.)

TERMINALS: Readily solderable, corrosion resistant, suitable for slip-on terminals.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	56.59	57.66	2.228	2.270
B	43.82	44.83	1.725	1.765
C	21.59	22.61	0.850	0.890
D	3.43	3.78	0.135	0.149
F	16.00	17.02	0.630	0.670
G	32.51	33.53	1.280	1.320
H	21.91	22.41	0.8625	0.8825
J	43.94 BSC		1.730 BSC	
K	12.88	13.89	0.507	0.547
L	7.24	7.49	0.285	0.295
Q	3.94	4.19	0.155	0.165
R	43.82	44.83	1.725	1.765

NOTES:
1. DIM "L" IS 6.35 (0.250) DEEP; DIM "Q" IS THRU HOLE.
2. MOUNTING HOLES WITHIN 0.25 mm (0.010) DIA OF TRUE POSITION AT MAXIMUM MATERIAL CONDITION.

CASE 298-02

FIGURE 1 – FORWARD VOLTAGE

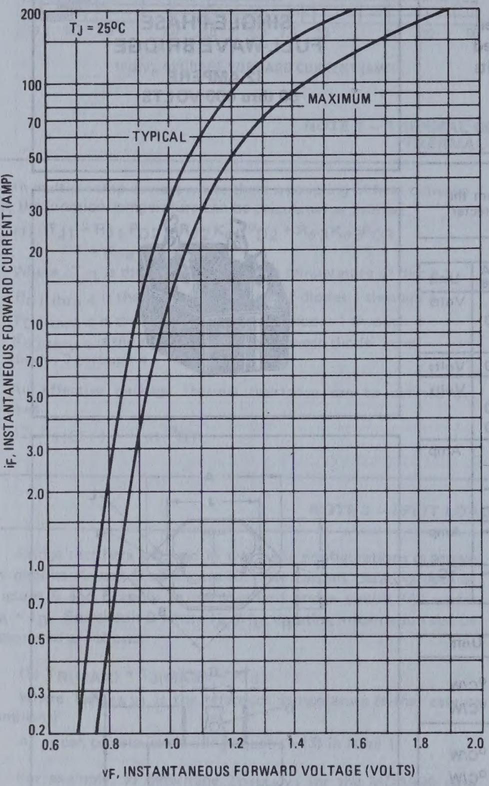


FIGURE 2 – MAXIMUM SURGE CAPABILITY

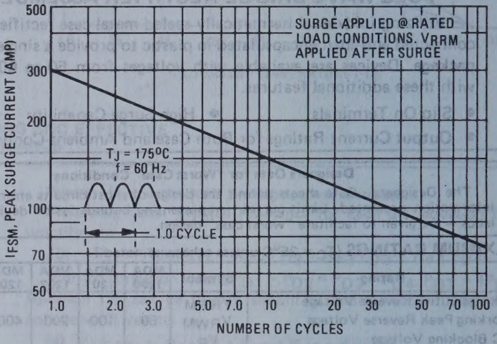


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

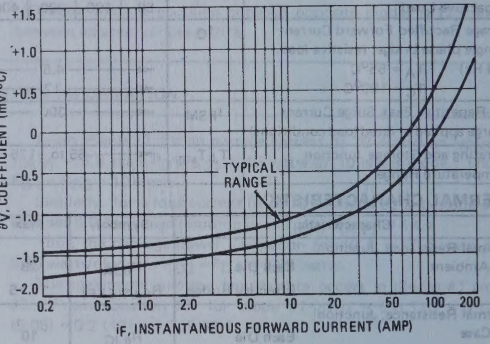
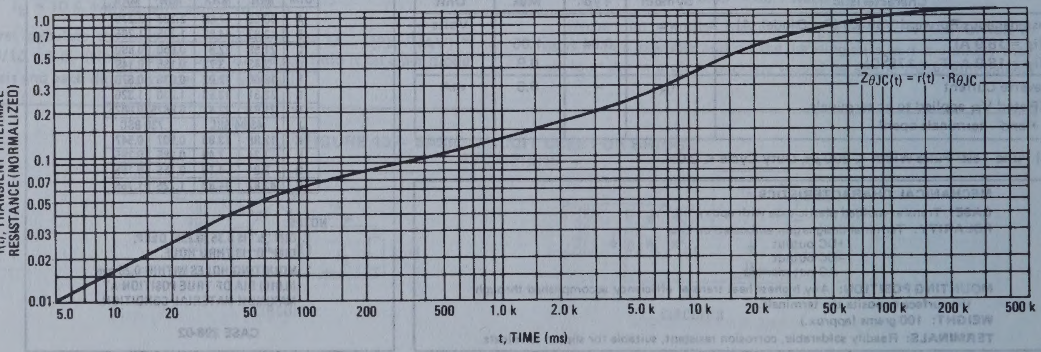


FIGURE 4 – TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – AMBIENT TEMPERATURE DERATING

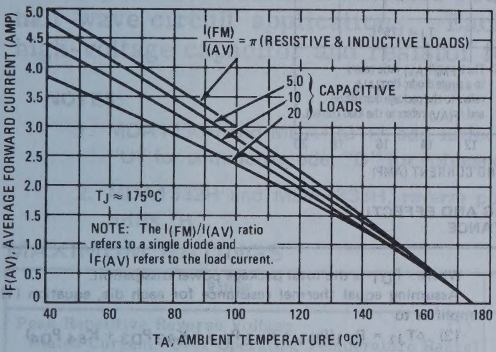
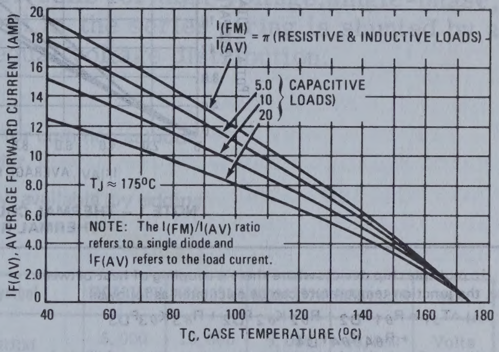


FIGURE 6 – CASE TEMPERATURE DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 – RECTIFICATION WAVEFORM EFFICIENCY

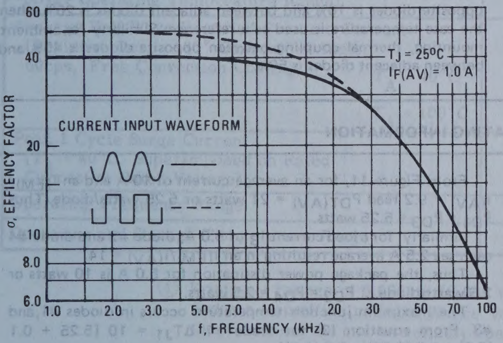


FIGURE 8 – CAPACITANCE

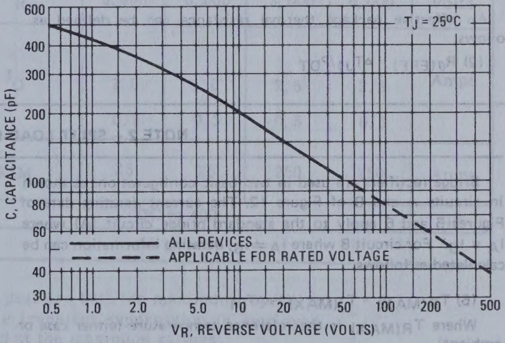


FIGURE 9 – REVERSE RECOVERY TIME

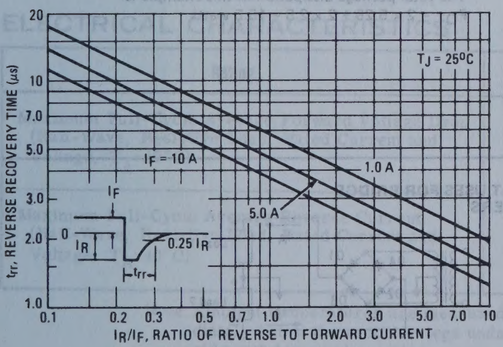


FIGURE 10 – FORWARD RECOVERY TIME

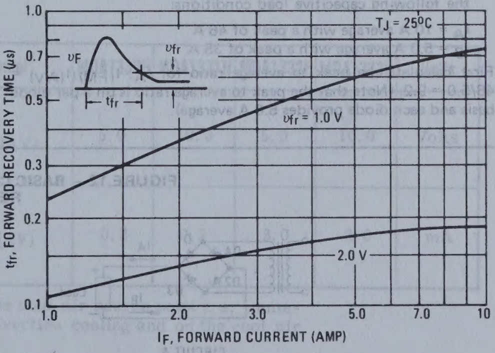
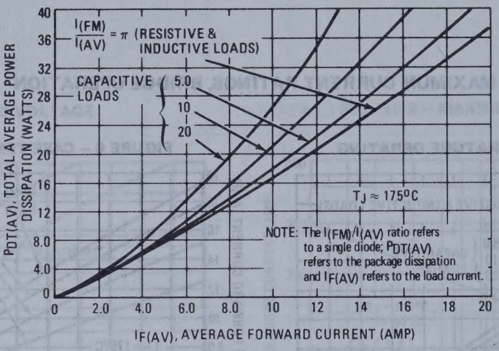


FIGURE 11 – POWER DISSIPATION



NOTE: The $I_{(FM)}/I_{(AV)}$ ratio refers to a single diode; $P_{DT(AV)}$ refers to the package dissipation and $I_{F(AV)}$ refers to the load current.

NOTE 1 – THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D2} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1

$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of diodes 1 through 4.

$P_{D1 \text{ thru } 4}$ is the power dissipated in diodes 1 through 4

$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the condition where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_{D1}$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} \; (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

For the MDA1200 rectifier assembly, thermal coupling between opposite diodes is 10% and between adjacent diodes is 20% when the case temperature is used as a reference. Similarly for ambient mounting, thermal coupling between opposite diodes is 45% and between adjacent diodes is 50%.

NOTE 2 – SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown in circuits A and B of Figure 12. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

(5) $T_{R(MAX)} = T_{J(MAX)} - \Delta T_{J1}$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the MDA1200 with the following capacitive load conditions:

I_A = 10 A average with a peak of 46 A
I_B = 5.0 A average with a peak of 35 A

First calculate the peak to average ratio for I_A. $I_{(FM)}/I_{(AV)}$ = 46/5.0 = 9.2. (Note that the peak to average ratio is on a per diode basis and each diode provides 5.0 A average).

From Figure 11, for an average current of 10 A and an $I_{(FM)}/I_{(AV)} = 9.2$ read $P_{DT(AV)} = 21$ watts or 5.25 watts/diode. Thus $P_{D1} = P_{D3} = 5.25$ watts.

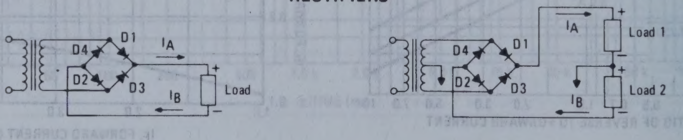
Similarly, for a load current I_B of 5.0 A, diode #2 and diode #4 each see 2.5 A average resulting in an $I_{(FM)}/I_{(AV)} = 14$.

Thus, the package power dissipation for 5.0 A is 10 watts or 2.5 watts/diode. $\therefore P_{D2} = P_{D4} = 2.5$ watts.

The maximum junction temperature occurs in diodes #1 and #3. From equation (3) for diode #1 $\Delta T_{J1} = 10\ [5.25 + 0.1\ (2.5) + 0.2\ (5.25) + 0.2\ (2.5)]$.

$\Delta T_{J1} \approx 70^\circ C$
Thus $T_{C(MAX)} = 175 - 65 = 105^\circ C$
The total package dissipation in this example is:
$P_{DT} = 2 \times 5.25 + 2 \times 2.5 = 15.5$ watts

FIGURE 12 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS

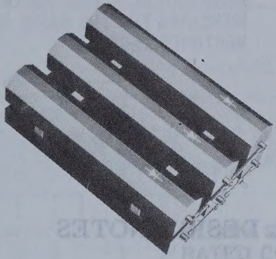


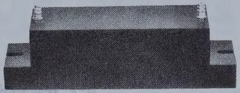
CIRCUIT A

CIRCUIT B

HIGH VOLTAGE SILICON RECTIFIER MOLDED ASSEMBLIES

MDA1330H
MDA1331H
MDA1332H
MDA1333H





Compensated series-connected rectifier cells for high-voltage, single-phase, half-wave circuit applications. Each cell in the series string is shunted by a high-voltage capacitor and resistor for equal voltage distribution.

NOTES:

1. MDA1330H and MDA1331H, add suffix "C" for common cathode, "U" for common anode, "D" for voltage doubler.
2. MDA1332H and MDA1333H, reverse polarity available by adding suffix "R".

MAXIMUM RATINGS

Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Peak Repetitive Reverse Voltage ① (Rated Current, Over Operating Temperature Range)	V_{RRM}	5,000	10,000	5,000	10,000	Volts
RMS Reverse Voltage (Rated Current Over the Complete Operating Temperature Range)	$V_{R(RMS)}$	3,500	7,000	3,500	7,000	Volts
DC Blocking Voltage ② (Over Operating Temperature Range)	V_R	3,000	6,000	3,000	6,000	Volts
Average Half Wave Rectified Forward Current (Resistive Load, 180° Conduction Angle, 60cps, Free Convection Cooling) T_A = 40°C	I_O	1.0	1.0	2.5	2.5	Amps
T_A = 100°C		0.3	0.3	0.5	0.5	
Peak 1 Cycle Surge Current (T_A = 40°C, Superimposed on Rated Current at Rated Voltage)	I_{FSM}	25	25	250	250	Amps
Operating Frequency Range		DC to 400				cps
Operating and Storage Temperature Range		-55 to +110				°C

① $V_{RM(rep)}$ ratings of 5,000 or 10,000 volts peak are both the maximum repetitive and non-repetitive ratings. Where voltage transient suppression is employed, these assemblies can be reliably operated at the maximum ratings.

② The DC Blocking Voltage rating (V_R), is established by the continuous power dissipation ratings of the shunting resistors and is not a function of the series rectifiers.

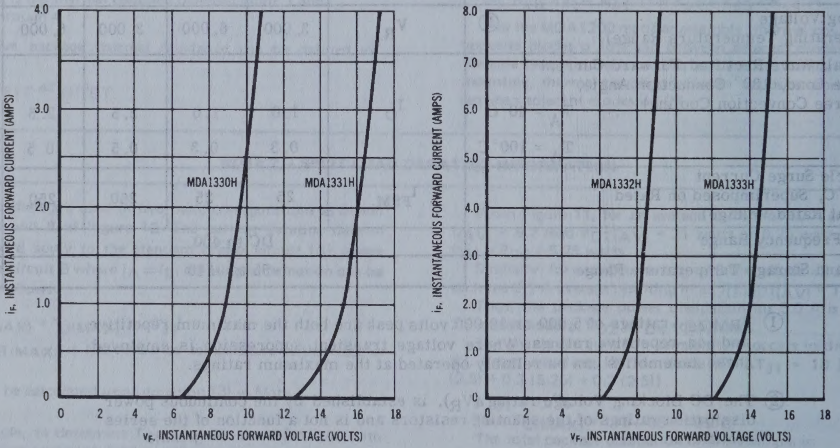
ELECTRICAL CHARACTERISTICS

Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Maximum Full-Cycle Average Forward Voltage Drop (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$V_{F(AV)}$	5.0	10.0	5.0	10.0	Volts
Maximum Full-Cycle Average Reverse Current (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$I_{R(AV)}$	0.2	0.2	3.0	3.0	mA

Note: Ambient temperatures are measured at the cold air source point i.e. immediately below the rectifier legs under convection cooling and on the cool air side with forced air cooling.

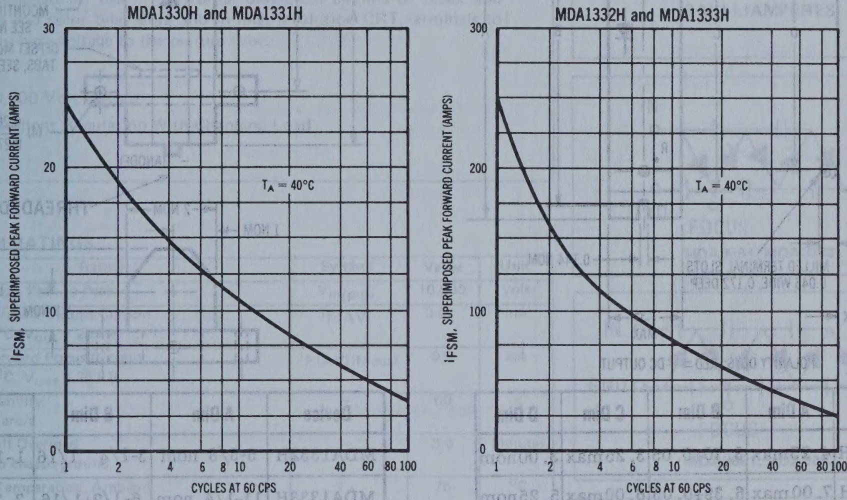
ELECTRICAL DESIGN NOTES

1. For single-phase, full-wave circuits using "Series 1300" stacks, multiply the current ratings given for the half-wave by two.
2. For three-phase, full-wave and half-wave circuits, multiply given current ratings for single-phase, half-wave by two and one half.
3. For capacitive loads, sufficient surge and capacitor inrush current protection must be employed. Recurrent peak currents up to six times the single-phase average output-current ratings can be safely sustained when the average value of these peaks are held at or below the rated average output. Non-repetitive peak currents must be held to the maximum surge ratings.

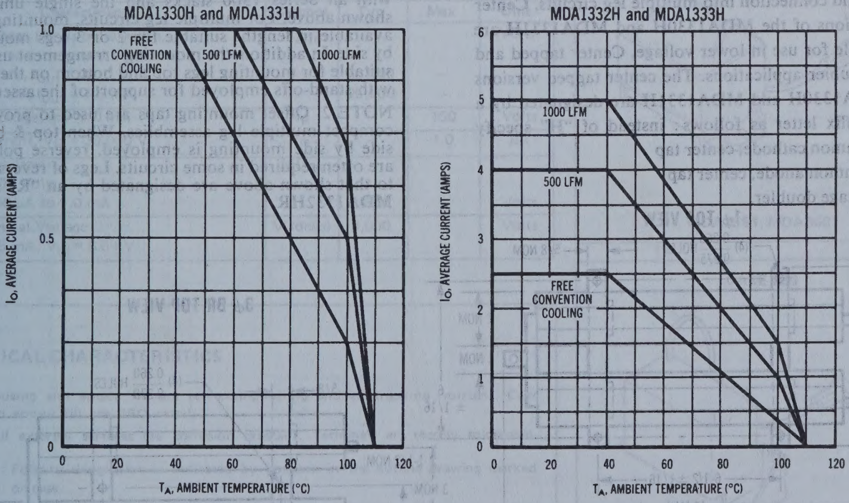


TYPICAL FORWARD CHARACTERISTICS
($T_J = 25^{\circ}C$)

MAXIMUM SURGE CURRENT
RATED CONDITIONS

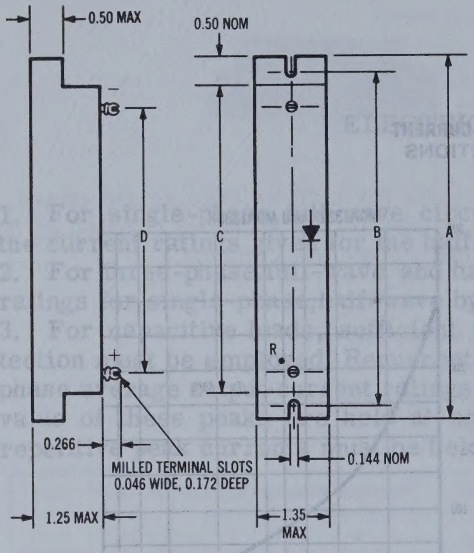


MAXIMUM AVERAGE HALF-WAVE RECTIFIED CURRENT
(RESISTIVE OR INDUCTIVE LOAD, 180° CONDUCTION ANGLE, 60 CPS)



HIGH VOLTAGE SILICON RECTIFIERS (continued)

MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1330H AND MDA1331H RECTIFIER LEGS.

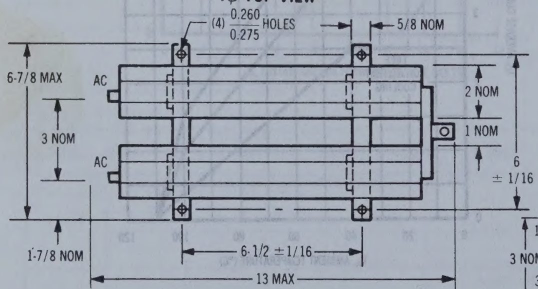

0.50 MAX
0.50 NOM
−
+
D
C
B
A
R
0.266
MILLED TERMINAL SLOTS 0.046 WIDE, 0.172 DEEP
0.144 NOM
1.25 MAX
1.35 MAX

POLARITY DOTS: RED=+DC OUTPUT

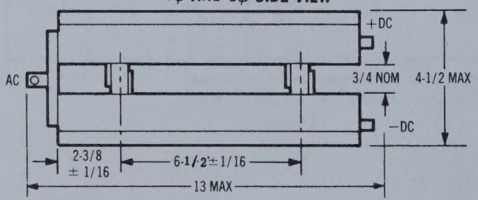
Device	A Dim	B Dim	C Dim	D Dim
MDA1330H	4.25max	3.70±0.05	3.25max	3.00nom
MDA1331H	7.00max	6.39±0.05	6.00max	5.25nom

NOTES: These basic rectifier legs are suitable for chassis mounting and connection into multiple leg circuits. Center tapped versions of the MDA1330H and MDA1331H are also available for use in lower voltage, Center tapped and Voltage Doubler applications. The center tapped versions of the MDA1330H and MDA1331H are designated by a different suffix letter as follows: instead of "H" specify
"C" for common cathode, center tap
"U" for common anode, center tap
"D" for voltage doubler.

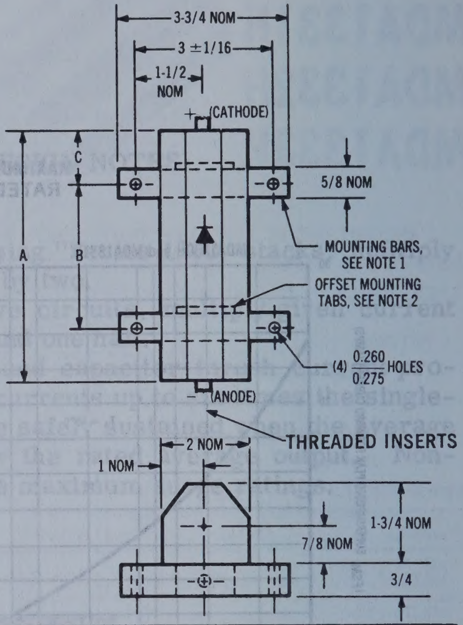
1φ TOP VIEW


(4) 0.260/0.275 HOLES
5/8 NOM
6-7/8 MAX
AC
3 NOM
AC
2 NOM
1 NOM
6 ± 1/16
1-7/8 NOM
6-1/2 ± 1/16
13 MAX

1φ AND 3φ SIDE VIEW


+DC
AC
3/4 NOM
4-1/2 MAX
−DC
2-3/8 ± 1/16
6-1/2 ± 1/16
13 MAX

MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1332H AND MDA1333H RECTIFIER LEGS.

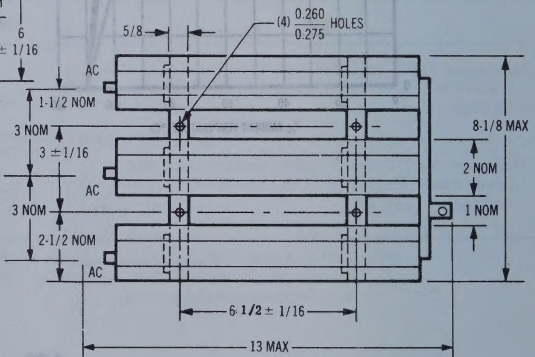

3-3/4 NOM
3 ±1/16
1-1/2 NOM
+ (CATHODE)
C
5/8 NOM
MOUNTING BARS, SEE NOTE 1
A
B
OFFSET MOUNTING TABS, SEE NOTE 2
(4) 0.260/0.275 HOLES
− (ANODE)
THREADED INSERTS
2 NOM
1 NOM
1-3/4 NOM
7/8 NOM
3/4

Device	A Dim	B Dim	C Dim
MDA1332H	5-5/8 nom	3-1/4 1/16	1-1/8 nom
MDA1333H	11-1/4 nom	6-1/2±1/16	2-3/8 nom

NOTE 1. Insulated mounting bars are supplied with all Series 1300 stacks and the single unit bar is shown above. For multiple leg circuits, mounting bars are available in lengths suitable for 2 or 3 legs mounted side by side. In addition, the mounting arrangement used is also suitable for mounting legs top and bottom on the same bar with stand-offs employed for support of the assembly.

NOTE 2. Offset mounting taps are used to provide more compact multiple leg assemblies. When top & bottom or side by side mounting is employed, reverse polarity legs are often required in some circuits. Legs of reverse polarity to that shown above are designated by an "R" suffix, i.e. MDA1332HR.

3φ BR TOP VIEW


(4) 0.260/0.275 HOLES
5/8
AC
1-1/2 NOM
3 NOM
3 ±1/16
AC
3 NOM
2-1/2 NOM
AC
8-1/8 MAX
2 NOM
1 NOM
6-1/2 ± 1/16
13 MAX

MDA1505 series

For Specifications, See MDA942 Data.

MDA1591

For Specifications, See MDA942 Data.

MDA3551, MDA3661, MDA3552, MDA3662

HIGH VOLTAGE TRIPLER ASSEMBLIES

. . . designed for use in horizontal deflection circuits of black and white and color television, and in high resolution CRT terminals to supply high voltage to the picture tube.

- 30,000 Volt Output
- Excellent Regulation With Changing Load

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage, Peak-to-Peak	$V_{in(p-p)}$	10,000	Volts
Average Forward Output Current $T_A = 75^oC$, $V_{out} = 25$ kV	$I_{F(AV)}$	3.0*	mA
Average Forward Focus Current $T_A = 75^oC$, $V_{out} = 25$ kV	$I_{F(AV)(focus)}$	0.5	mA
Arcing Capability 30 kV, 1 arc/s	–	60	s
Short Circuit Overload Output to chassis ground	–	3.0	Minutes
Operating Temperature, Ambient	T_A	75	°C

*Derate to zero output with $V_{out} = 30$ kV.

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Output Voltage (11 µs pulse width, 15.75 kHz repetition rate)	V_{out}			Volts
$V_{in} = 10$ kV, $I_{out} = 0$		30,000	–	
$V_{in} = 8.5$ kV, $I_{out} = 1.5$ mA		25,000	–	
Forward Voltage, $i_F = 2.0$ mA	v_F	–	150	Volts
Reverse Current, $V_R = 30,000$ V	I_R	–	1.0	µA
Voltage Regulation $V_{in} = 8500$ Volts, $I_{out} = 100$ µA to 1.0 mA	ΔV_{out}	1,800	–	Volts
Focus Terminal Voltage $I_{out} = 1.5$ mA, $V_{in} = 8.5$ kV	V(focus)	8,000	–	Volts

MECHANICAL CHARACTERISTICS

CASE: Housing and epoxy fill are self-extinguishing and arc-tracking resistant. Case and epoxy fill are SEO rated.

FINISH: All external surfaces are corrosion resistant. Terminals are readily solderable.

POLARITY: Polarity designation is indicated by position in the outline drawing marked on case.

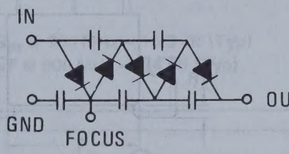
MOUNTING POSITION: Any. Terminals must be adequate distance from ground potential. Case may be mounted on the chassis.

WEIGHT: (approximate) 9.7 oz. for Case 280; 11.7 oz. for Case 281.

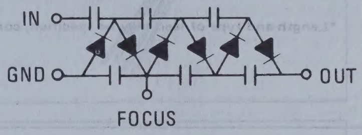
ANODE CONNECTOR: Hobson Bros., Type P125-23

VOLTAGE TRIPLERS

30,000 VOLTS
3 MILLIAMPERES

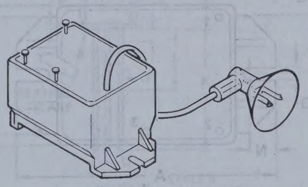


MDA3551, MDA3552



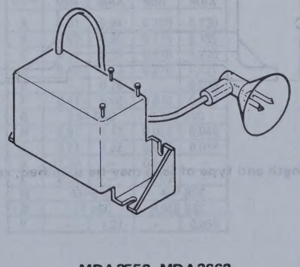
MDA3661, MDA3662

CASE 281

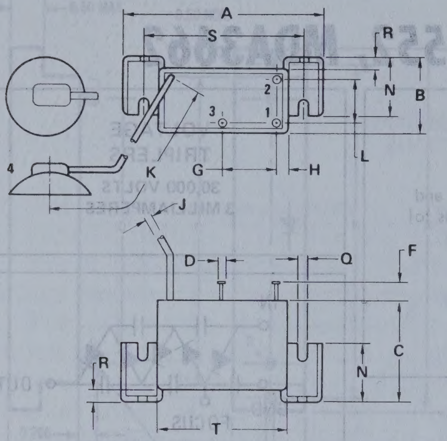


MDA3551, MDA3661

CASE 280



MDA3552, MDA3662

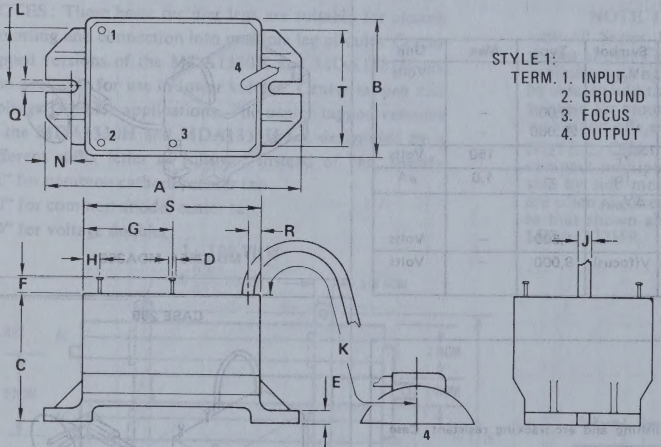


STYLE 1:
TERM. 1. INPUT
2. GROUND
3. FOCUS
4. OUTPUT

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	107.29	108.56	4.224	4.274
B	41.02	41.53	1.615	1.635
C	53.72	54.23	2.115	2.135
D	3.68	3.94	0.145	0.155
F	9.40	9.65	0.370	0.380
G	31.12	31.37	1.225	1.235
H	3.68	3.94	0.145	0.155
J	3.81	5.08	0.150	0.200
K	304.80	381.00	12.000	15.000
L	27.31	27.56	1.075	1.085
N	31.50	32.00	1.240	1.260
Q	4.70	4.95	0.185	0.195
R	6.10	6.60	0.240	0.260
S	85.60	85.85	3.370	3.380
T	69.85	70.10	2.750	2.760

*Length and type of lead may be specified, consult factory.

Case 280
MDA3552, MDA3662



STYLE 1:
TERM. 1. INPUT
2. GROUND
3. FOCUS
4. OUTPUT

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	98.68	100.20	3.885	3.945
B	53.09	53.59	2.090	2.110
C	49.28	49.78	1.940	1.960
D	3.56	3.94	0.140	0.155
E	4.50	5.00	0.177	0.197
F	5.08	9.62	0.200	0.380
G	34.04	34.54	1.340	1.360
H	6.10	6.60	0.240	0.260
J	3.81	5.08	0.150	0.200
K	304.80	381.00	12.000	15.000
L	21.84	22.35	0.860	0.880
N	7.37	7.87	0.290	0.310
Q	4.70	4.95	0.185	0.195
R	4.83	5.33	0.190	0.210
S	68.71	69.22	2.705	2.725
T	43.94	44.45	1.730	1.750

*Length and type of lead may be specified, consult factory.

Case 281
MDA3551, MDA3661

MFE130 thru MFE132

For Specifications, See MPF130 Data.

MFE590 (SILICON)
MFE591

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED DMOS FIELD-EFFECT TRANSISTORS

Enhancement mode (Type C) dual gate double-diffused metal oxide transistors designed for UHF amplifier and mixer applications. Especially suited for UHF TV tuner applications.

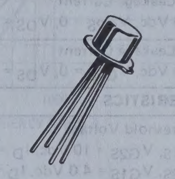
This series features high-volume production capability using ion implantation techniques. Characteristics of major importance are:

- High UHF Power Gain @ 900 MHz –
  G_{ps} = 12.5 dB (Min) MFE591
  = 10.5 dB (Min) MFE590
- Low UHF Noise Figure @ 900 MHz –
  NF = 6.0 dB (Max) MFE591
  = 8.0 dB (Max) MFE590
- Low Input Capacitance @ 1.0 MHz –
  C_{iss} = 3.0 pF (Max) MFE591
  = 3.5 pF (Max) MFE590
- Low Output Capacitance @ 1.0 MHz –
  C_{oss} = 2.0 pF (Max) MFE591
  = 2.5 pF (Max) MFE590
- Diode Protected Gates
- Ion Implanted

N-CHANNEL
DUAL GATE

DOUBLE-DIFFUSED METAL OXIDE FIELD-EFFECT TRANSISTORS (DMOS)

G_{ps} @ 900 MHz – 15.3 dB (Typ)
NF @ 900 MHz – 4.4 dB (Typ)

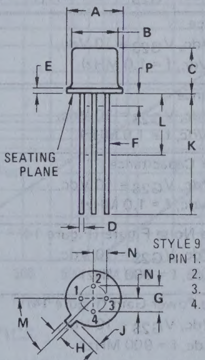


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG1} V_{DG2}	30 30	Vdc
Drain Current	I_D	30	mAdc
Gate Current	I_{G1} I_{G2}	10 10	mAdc
Total Power Dissipation @ $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	300 1.71	mW mW/$^{\circ}C$
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	-65 to +200	$^{\circ}C$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	585	$^{\circ}C/W$



STYLE 9
PIN 1. DRAIN
2. GATE 2
3. GATE 1
4. SOURCE, SUBSTRATE AND CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.) Substrate Connected to Source

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 1.0 μAdc, V_{G1} = V_{G2} = 0)	$V_{(BR)DSS}$	25	–	–	Vdc
Gate 1 – Source Breakdown Voltage (I_{G1} = 10 μAdc, V_{G2S} = 0)	$V_{(BR)G1S}$	10	–	–	Vdc
Gate 2 – Source Breakdown Voltage (I_{G2} = 10 μAdc, V_{G2S} = 0)	$V_{(BR)G2S}$	12	–	–	Vdc
"Off" Drain Current (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0)	$I_{D(off)}$	–	–	1.0	μAdc
Gate 1 Reverse Leakage Current (V_{G1S} = 5.0 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	–	–	50	nAdc
Gate 2 Reverse Leakage Current (V_{G2S} = 5.0 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	–	–	50	nAdc
ON CHARACTERISTICS					
Gate Source Threshold Voltage (V_{DS} = V_{G1S}, V_{G2S} = 10 Vdc, I_D = 1.0 μAdc) (V_{DS} = V_{G2S}, V_{G1S} = 4.0 Vdc, I_D = 1.0 μAdc)	$V_{G1S(TH)}$ $V_{G2S(TH)}$	0.1 0.1	– –	– –	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance MFE591 (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, f = 1.0 kHz) MFE590	y_{fs}	10 8.0	–	20 20	mmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, MFE591 V_{G1} = 2.5 Vdc, f = 1.0 MHz) MFE590	C_{iss}	– –	– –	3.0 3.5	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, MFE591 V_{G1} = 2.5 Vdc, f = 1.0 MHz) MFE590	C_{oss}	– –	– –	2.0 2.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, MFE591 V_{G1} = 2.5 Vdc, f = 1.0 MHz) MFE590	C_{rss}	– –	– –	0.02 0.025	pF
Common-Source Noise Figure (Figure 14) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, MFE591 I_D = 10 mAdc, f = 900 MHz) MFE590	NF	–	4.4 4.4	6.0 8.0	dB
Common-Source Power Gain (Figure 14) (V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, MFE591 I_D = 10 mAdc, f = 900 MHz) MFE590	G_{ps}	12.5 10.5	15.3 15.3	– –	dB

COMMON-SOURCE CHARACTERISTICS

(V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc, $T_{channel}$ = 25°C)

FIGURE 1 – INPUT ADMITTANCE – y_{11}

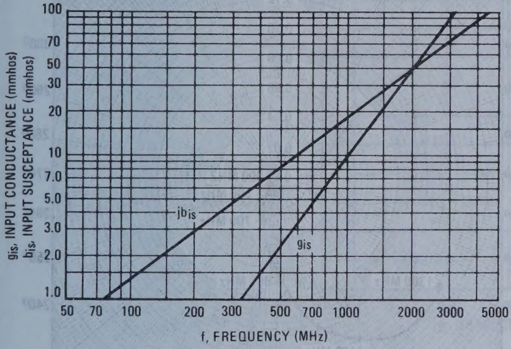


FIGURE 2 – REVERSE TRANSFER ADMITTANCE – y_{12}

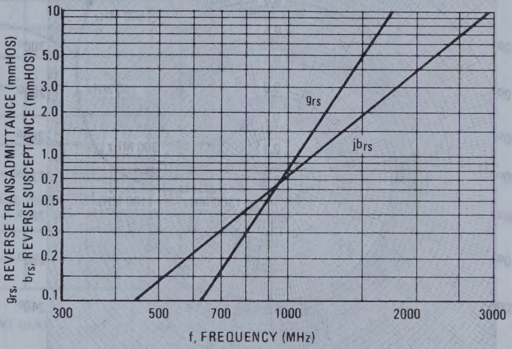


FIGURE 3 – FORWARD TRANSADMITTANCE – y_{21}

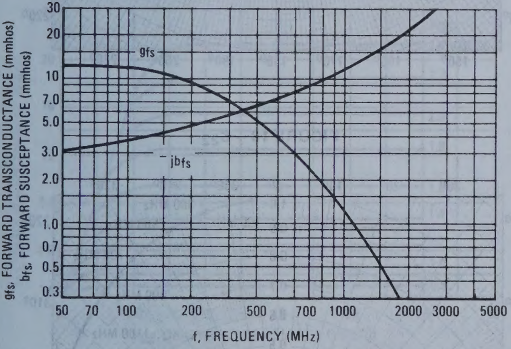
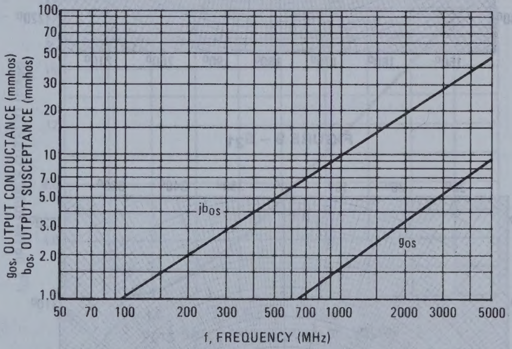


FIGURE 4 – OUTPUT ADMITTANCE – Y22



POWER GAIN AND NOISE FIGURE CHARACTERISTICS

(V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, f = 900 MHz)

FIGURE 5 – POWER GAIN

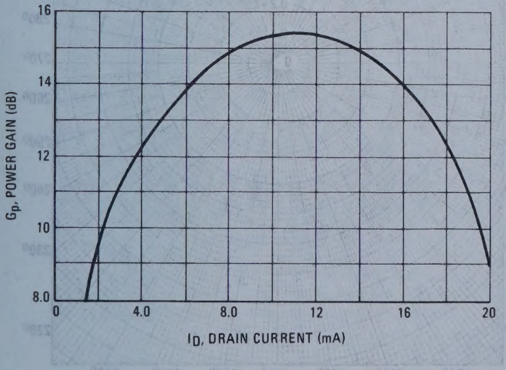
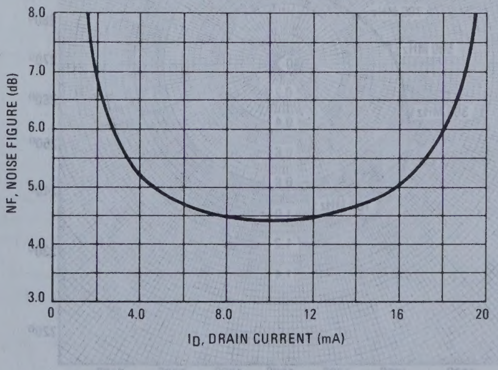


FIGURE 6 – NOISE FIGURE



S PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 10 Vdc, I_D = 10 mAdc)

FIGURE 7 – S_{11}

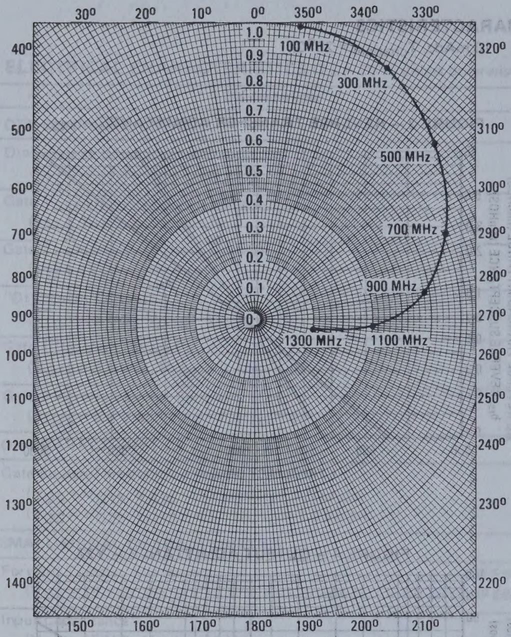


FIGURE 8 – S_{12}

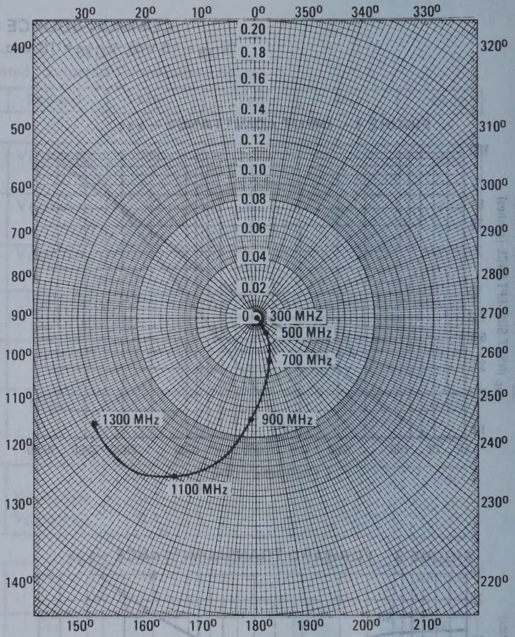


FIGURE 9 – S_{21}

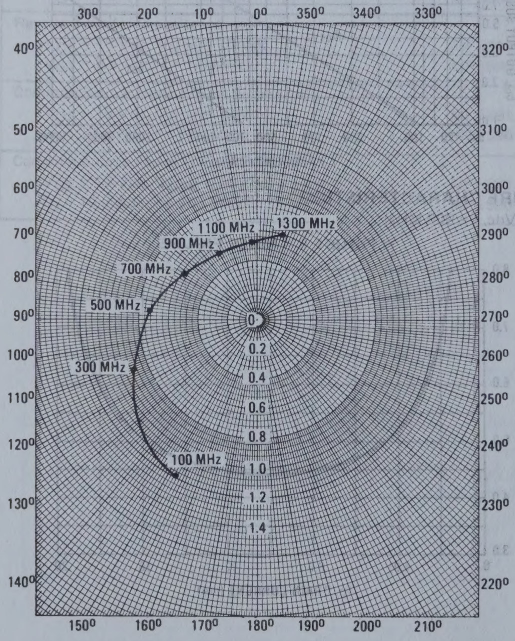
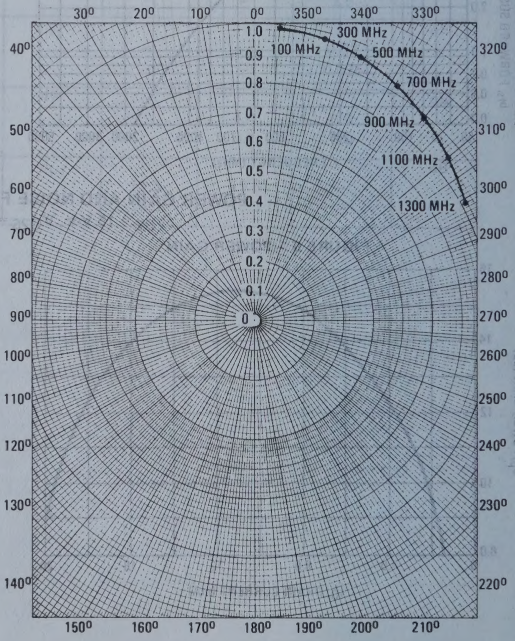


FIGURE 10 – S_{22}



DRAIN CHARACTERISTICS

FIGURE 11 – FORWARD TRANSFER ADMITTANCE

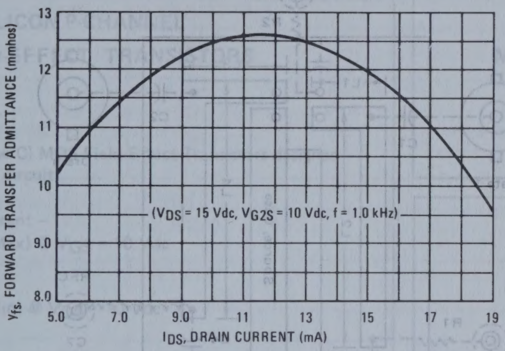


FIGURE 12 – DRAIN-SOURCE CURRENT

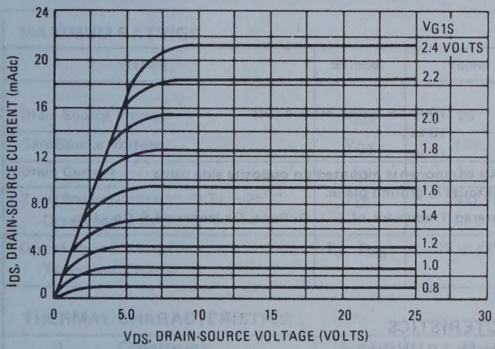


FIGURE 13 – EFFECTS OF GATE 1 VOLTAGE ON DRAIN-SOURCE CURRENT

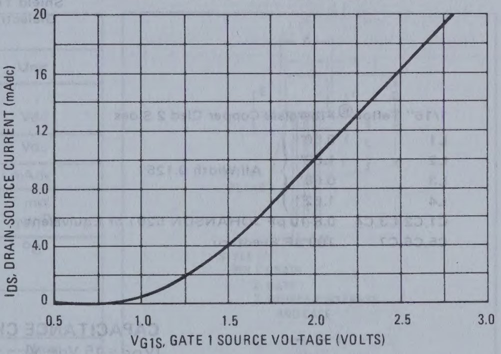
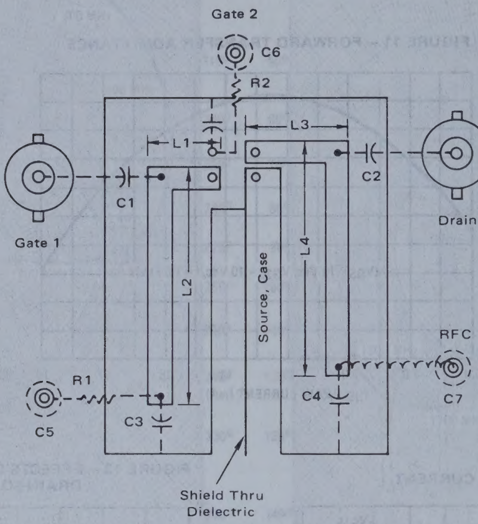


FIGURE 14 – 900 MHz TEST FIXTURE


Gate 2
C6
R2
L1
L3
C2
C1
Gate 1
Drain
L2
Source, Case
L4
RFC
R1
C5
C3
C4
C7
Shield Thru Dielectric

1/16'' Teflon® Fiberglass Copper Clad 2 Sides

L1	0.50''	All Width 0.125''
L2	1.62''	
L3	0.68''	
L4	1.62''	
C1,C2,C3,C4	0.8-10 pF JOHANSON 5201 or Equivalent	
C5,C6,C7	100 pF Feedthru	

C8	1000 pF Bare Ceramic Disc
R1,R2	10 kΩ
RFC	10 μH

Note: All components mounted on opposite side using cutouts in ground plane.

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CAPACITANCE CHARACTERISTICS

(V_{DS} = 15 Vdc, V_{G2} = 10 Vdc, f = 1.0 MHz)

FIGURE 15 – GATE ONE

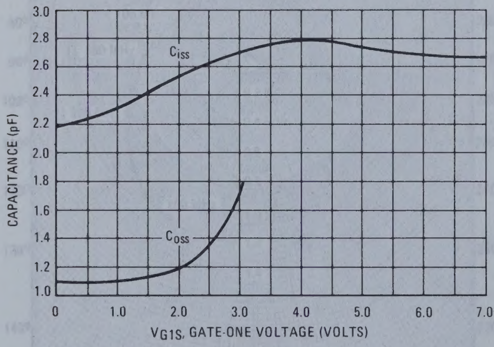
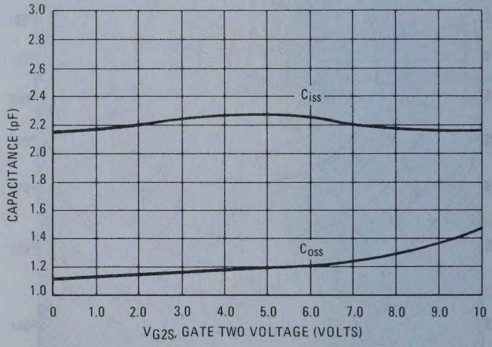


FIGURE 16 – GATE TWO



MFE823 (SILICON)

SILICON P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode (Type C) MOS Field-Effect Transistors designed for use in smoke detector circuits.

- Low Gate Reverse Current —
  I_{GSS} = 1.0 pAdc (Max) @ V_{GS} = 10 Vdc
- High Sensitivity —
  Y_{fs} = 1.0 mmho (Min) @ V_{DS} = 10 Vdc

P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	30	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 1.71	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

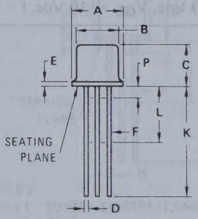
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	584	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	$^oC/W$

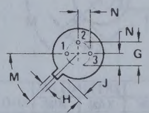
HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.



STYLE 11:
PIN 1. DRAIN
2. GATE
3. SOURCE,SUBSTRATE AND CASE



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 BSC		45^0 BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_D = −10 μAdc, V_{GS} = 0 Vdc)	BV_{DSS}	-25	–	Vdc
Zero-Gate Voltage Drain Current (V_{DS} = −10 Vdc, V_{GS} = 0)	I_{DSS}	–	-20	nAdc
Gate Reverse Current (V_{GS} = −10 Vdc, V_{DS} = 0)	I_{GSS}	–	1.0	pAdc
ON CHARACTERISTICS				
Gate-Source Voltage (V_{DS} = −10 Vdc, I_D = −10 μAdc)	$V_{GS(TH)}$	-2.0	-6.0	Vdc
Drain Current (V_{DS} = −10 Vdc, V_{GS} = −10 Vdc)	$I_{D(on)}$	-3.0	–	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = −10 Vdc, I_D = −2.0 mAdc, f = 1.0 kHz)	y_{fs}	1000	–	μmhos
Input Capacitance (V_{DS} = −10 Vdc, V_{GS} = −10 Vdc, f = 1.0 MHz)	C_{iss}	–	6.0	pF
Reverse Transfer Capacitance (V_{DS} = −10 Vdc, V_{GS} = −10 Vdc, f = 1.0 MHz)	C_{rss}	–	1.5	pF

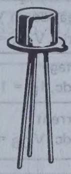
MFE824 (SILICON)

SILICON N-CHANNEL
MOS FIELD-EFFECT TRANSISTORS

Depletion-Enhancement Mode (Type B) MOS Field-Effect Transistors designed for use in smoke detector circuits.

- Low Gate Reverse Current — I_{GSS} = 1.0 pAdc (Max) @ V_{GS} = 10 Vdc
- High Sensitivity — Y_{fs} = 1.0 mmho (Min) @ V_{DS} = 10 Vdc

N-CHANNEL
MOS FIELD-EFFECT
TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	30	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

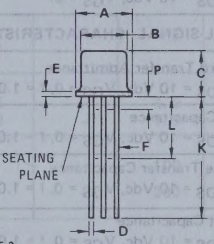
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	584	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	°C/W

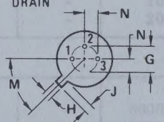
HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.



STYLE 2
PIN 1. SOURCE, SUBSTRATE, CASE
2. GATE
3. DRAIN



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (I_C = 1.0 μAdc, V_{GS} = −8.0 Vdc)	$V_{(BR)DSX}$	20	–	Vdc
Gate-Source Voltage (V_{DS} = 10 Vdc, I_D = 1.0 nAdc)	V_{GS}	–	-6.0	Vdc
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0)	I_{GSS}	–	1.0	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	1.0	15	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}	1.0	4.0	mmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	0.7	pF
Output Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	–	2.5	pF

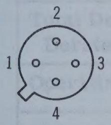
MFE2000 (SILICON)
MFE2001

Silicon N-channel junction field-effect transistor designed for VHF/UHF amplifier applications.

CASE 20
(TO-72)

Active elements isolated from case

STYLE 1
PIN 1. SOURCE
2. DRAIN
3. GATE
4. CASE LEAD



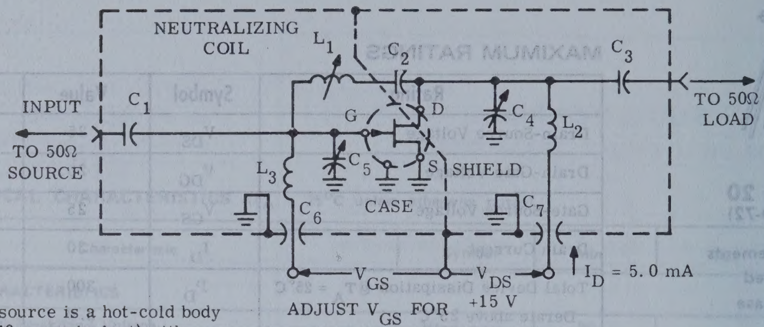
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	300	mW
Derate above 25°C		2.0	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = -1.0\ \mu$Adc, $V_{DS} = 0$)		$V_{(BR)GSS}$	25	-	-	Vdc
Gate-Source Voltage ($I_D = 0.5$ mAdc, $V_{DS} = 15$ Vdc)	MFE2000 MFE2001	V_{GS}	0.5 3.0	- -	4.0 7.5	Vdc
Gate Reverse Current ($V_{GS} = -20$ Vdc, $V_{DS} = 0$)		I_{GSS}	-	-	100	pAdc
($V_{GS} = -20$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)			-	-	200	nAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	MFE2000 MFE2001	I_{DSS}	4.0 8.0	- -	10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	MFE2000 MFE2001	$\lvert y_{fs}\rvert$	2500 4000	- -	6000 8000	µmhos
Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	MFE2000 MFE2001	$\lvert y_{os}\rvert$	- -	- -	50 75	µmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{iss}		-	5.0	pF
Output Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{oss}	-	-	2.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)		C_{rss}	-	-	1.0	pF
Small-Signal Power Gain (Figure 1) ($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 100 MHz)		G_{ps}	18	23	-	dB
($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 400 MHz)			10	14	-	
Noise Figure (Figure 1) ($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 100 MHz, $R_G \approx 1.0$ k ohm)		NF	-	1.6	2.0	dB
($V_{DS} = 15$ Vdc, $I_D = 4.0$ mAdc, f = 400 MHz, $R_G \approx 1.0$ k ohm)			-	3.3	4.0	

FIGURE 1 — 100 MHz and 400 MHz NEUTRALIZED AMPLIFIER


NEUTRALIZING COIL
L_1
C_2
C_3
INPUT
TO 50Ω SOURCE
C_1
G
D
C_4
L_2
TO 50Ω LOAD
L_3
C_5
S
SHIELD
C_6
CASE
C_7
V_{GS}
V_{DS}
+15 V
I_D = 5.0 mA

NOTE:

The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

ADJUST V_{GS} FOR

I_D = 5.0 mA

$V_{GS} < 0$ VOLTS

Reference Designation	VALUE	
	100 MHz	400 MHz
C_1	7.0 pF	1.8 pF
C_2	1000 pF	27 pF
C_3	3.0 pF	1.0 pF
C_4	1-12 pF	0.8-8.0 pF
C_5	1-12 pF	0.8-8.0 pF
C_6	0.0015 μF	0.001 μF
C_7	0.0015 μF	0.001 μF
L_1	3.0 μH*	0.2 μH**
L_2	0.25 μH*	0.03 μH**
L_3	0.14 μH*	0.022 μH**

* L_1 17 turns (approximately - depending on circuit layout), AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L_2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I. D.

L_3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I. D.

** L_1 6 turns approximately -(depending on circuit layout), AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

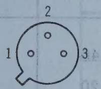
L_2 1 turn, AWG #16 enameled copper wire, 3/8" I. D.

L_3 1/2 turn, AWG #16 enameled copper wire, 1/4" I. D.

MFE2004 (SILICON)
MFE2005
MFE2006

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.

CASE 22
(TO-18)



STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE &CASE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

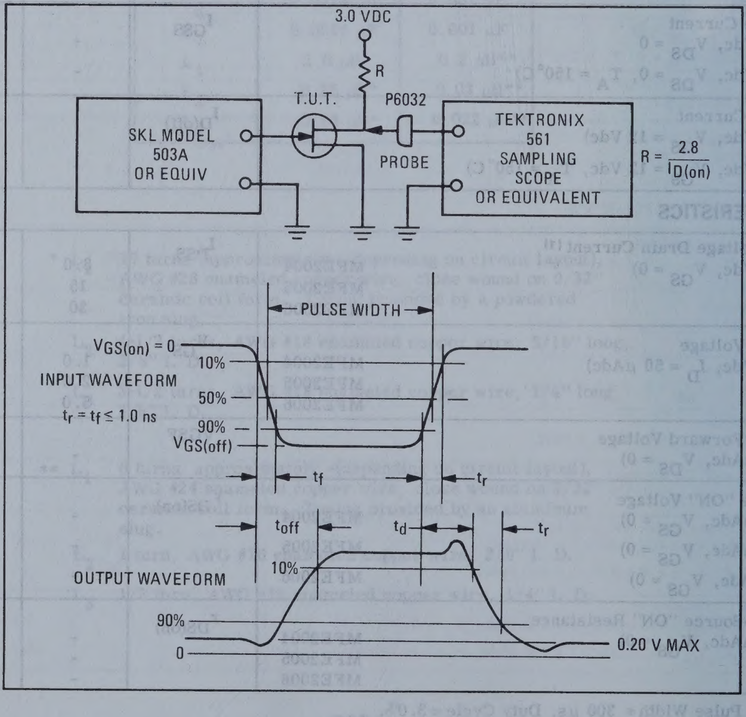
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	30	-	Vdc
Gate Reverse Current ($V_{GS} = 20$ Vdc, $V_{DS} = 0$ ($V_{GS} = 20$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)		I_{GSS}	- -	0.2 0.4	nAdc µAdc
Drain Cutoff Current ($V_{DS} = 20$ Vdc, $V_{GS} = 12$ Vdc) ($V_{DS} = 20$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 150°C$)		$I_{D(off)}$	- -	0.2 0.4	nAdc µAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (1) ($V_{DS} = 20$ Vdc, $V_{GS} = 0$)	MFE2004 MFE2005 MFE2006	I_{DSS}	8.0 15 30	- - -	mAdc
Gate-Source Voltage ($V_{DS} = 20$ Vdc, $I_D = 50\ \mu Adc$)	MFE2004 MFE2005 MFE2006	V_{GS}	1.0 2.0 5.0	6.0 8.0 10	Vdc
Gate-Source Forward Voltage ($I_G = 1.0$ mAdc, $V_{DS} = 0$)		VGSF	-	1.0	Vdc
Drain-Source "ON" Voltage ($I_D = 3.0$ mAdc, $V_{GS} = 0$) ($I_D = 6.0$ mAdc, $V_{GS} = 0$) ($I_D = 10$ mAdc, $V_{GS} = 0$)	MFE2004 MFE2005 MFE2006	$V_{DS(on)}$	- - -	0.4 0.4 0.4	Vdc
Static Drain-Source "ON" Resistance ($I_D = 1.0$ mAdc, $V_{GS} = 0$)	MFE2004 MFE2005 MFE2006	$r_{DS(on)}$	- - -	80 50 30	Ohms

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 3.0%.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2004	$r_{ds(on)}$	-	80	Ohms
	MFE2005		-	50	
	MFE2006		-	30	
Input Capacitance (V_{DS} = 0, V_{GS} = -12 Vdc, f = 1.0 MHz)		C_{iss}	-	16	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	MFE2004	C_{rss}	-	5.0	pF
(V_{DS} = 0, V_{GS} = 8.0 Vdc, f = 1.0 MHz)	MFE2005		-	5.0	
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	MFE2006		-	5.0	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1) (V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004	$t_{d(on)}$	-	20	ns
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		-	15	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		-	10	
Rise Time (See Figure 1) (V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004	t_r	-	40	ns
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		-	20	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		-	10	
Turn-Off Time (See Figure 1) (V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, $V_{GS(off)}$ = 6.0 Vdc)	MFE2004	t_{off}	-	80	ns
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, $V_{GS(off)}$ = 8.0 Vdc)	MFE2005		-	60	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MFE2006		-	40	

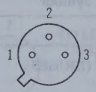
FIGURE 1 – SWITCHING TIMES TEST CIRCUIT


3.0 VDC
R
T.U.T.
P6032
PROBE
SKL MODEL
503A
OR EQUIV
TEKTRONIX
561
SAMPLING
SCOPE
OR EQUIVALENT
R = 2.8 / I_D(on)
PULSE WIDTH
V_GS(on) = 0
10%
50%
90%
V_GS(off)
INPUT WAVEFORM
t_r = t_f ≤ 1.0 ns
t_f
t_r
t_off
t_d
t_r
10%
OUTPUT WAVEFORM
90%
0
0.20 V MAX

MFE2007 (SILICON)
MFE2008
MFE2009

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.

CASE 22
(TO-18)

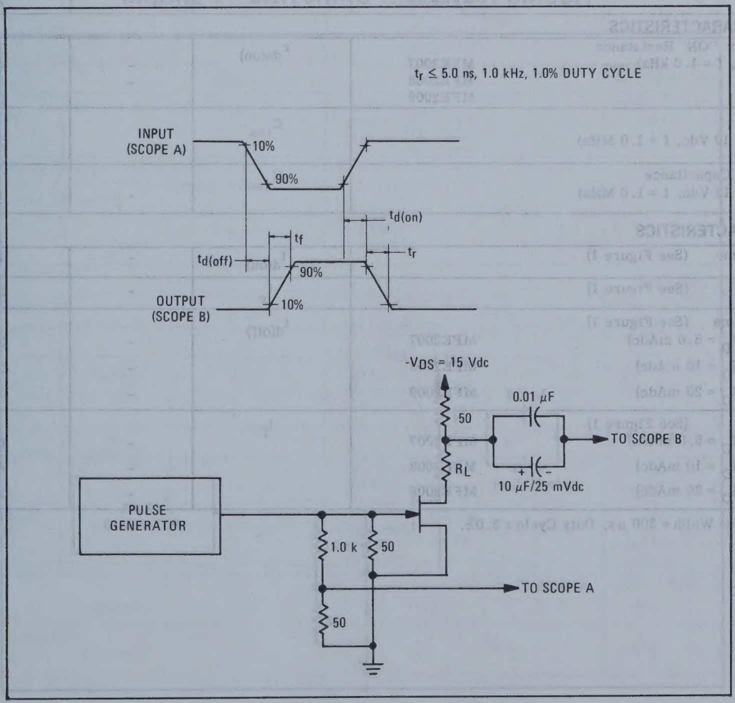


STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE &CASE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to + 175	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT


tr ≤ 5.0 ns, 1.0 kHz, 1.0% DUTY CYCLE
INPUT (SCOPE A)
10%
90%
td(on)
tf
tr
td(off)
90%
OUTPUT (SCOPE B)
10%
-VDS = 15 Vdc
0.01 μF
50
TO SCOPE B
RL
10 μF/25 mVdc
PULSE GENERATOR
1.0 k
50
TO SCOPE A
50

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

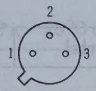
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 µAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	-	2.0	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)			-	4.0	µAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)		$I_{D(off)}$	-	2.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)			-	4.0	µAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current **(1)** (V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2007	I_{DSS}	8.0	-	mAdc
	MFE2008		20	-	
	MFE2009		50	-	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 1.0 µAdc)	MFE2007	V_{GS}	0.5	10	Vdc
	MFE2008		1.0	10	
	MFE2009		3.0	10	
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		VGSF	-	1.0	Vdc
Drain-Source "ON" Voltage (I_D = 5.0 mAdc, V_{GS} = 0)	MFE2007	$V_{DS(on)}$	-	0.75	Vdc
(I_D = 10 mAdc, V_{GS} = 0)	MFE2008		-	0.75	
(I_D = 20 mAdc, V_{GS} = 0)	MFE2009		-	0.75	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MFE2007	$r_{DS(on)}$		40	Ohms
	MFE2008		-	30	
	MFE2009		-	20	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2007	$r_{ds(on)}$	-	40	Ohms
	MFE2008		-	30	
	MFE2009			20	
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	-	30	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)		C_{rss}	-	15	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$	-	10	ns
Rise Time (See Figure 1)		t_r	-	6.0	ns
Turn-Off Delay Time (See Figure 1) (V_{DD} = 15 Vdc, I_D = 5.0 mAdc)	MFE2007	$t_{d(off)}$	-	35	ns
(V_{DD} = 15 Vdc, I_D = 10 mAdc)	MFE2008		-	20	
(V_{DD} = 15 Vdc, I_D = 20 mAdc)	MFE2009		-	12	
Fall Time (See Figure 1) (V_{DD} = 15 Vdc, I_D = 5.0 mAdc)	MFE2007	t_f	-	65	ns
(V_{DD} = 15 Vdc, I_D = 10 mAdc)	MFE2008		-	40	
(V_{DD} = 15 Vdc, I_D = 20 mAdc)	MFE2009		-	25	

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 3.0%.

MFE2010 (SILICON)
MFE2011
MFE2012

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.

CASE 22
(TO-18)

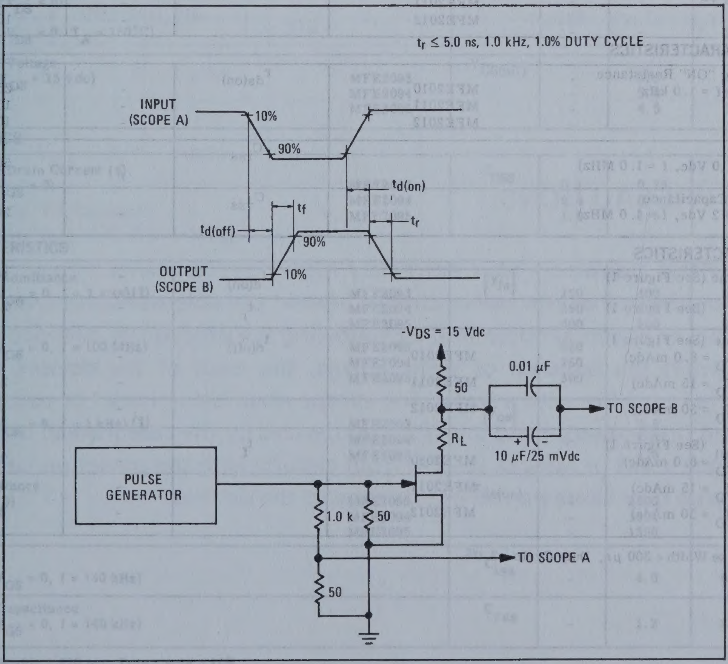


STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25° C	P_D	1.8 10	Watt mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT

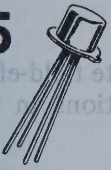

$t_r \leq 5.0$ ns, 1.0 kHz, 1.0% DUTY CYCLE
INPUT
(SCOPE A)
10%
90%
$t_{d(on)}$
t_f
t_r
$t_{d(off)}$
90%
OUTPUT
(SCOPE B)
10%
$-V_{DS}$ = 15 Vdc
50
0.01 μF
TO SCOPE B
R_L
10 μF/25 mVdc
PULSE
GENERATOR
1.0 k
50
TO SCOPE A
50

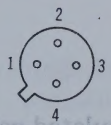
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 µAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)		I_{GSS}	-	3.0	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)			-	6.0	µAdc
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)		$I_{D(off)}$	-	3.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)			-	6.0	µAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (1) (V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2010	I_{DSS}	15	-	mAdc
	MFE2011		40	-	
	MFE2012		100	-	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 1.0 µAdc)	MFE2010	V_{GS}	0.5	10	Vdc
	MFE2011		1.0	10	
	MFE2012		3.0	10	
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		VGSF	-	1.0	Vdc
Drain-Source "ON" Voltage (I_D = 8.0 mAdc, V_{GS} = 0)	MFE2010	$V_{DS(on)}$	-	0.75	Vdc
(I_D = 15 mAdc, V_{GS} = 0)	MFE2011		-	0.75	
(I_D = 30 mAdc, V_{GS} = 0)	MFE2012		-	0.75	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	MFE2010	$r_{DS(on)}$	-	25	Ohms
	MFE2011		-	15	
	MFE2012		-	10	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2010	$r_{ds(on)}$	-	25	Ohms
	MFE2011		-	15	
	MFE2012		-	10	
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	-	50	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)		C_{rss}	-	20	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$	-	10	ns
Rise Time (See Figure 1)		t_r	-	6.0	ns
Turn-Off Delay Time (See Figure 1) (V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010	$t_{d(off)}$	-	35	ns
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		-	20	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		-	12	
Fall Time (See Figure 1) (V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010	t_f	-	75	ns
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		-	45	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		-	25	

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 3.0%.

MFE2093 (SILICON)
MFE2094
MFE2095





STYLE 3
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE LEAD

CASE 20
(TO-72)

Silicon N-channel junction field-effect transistors, designed for low-power audio-amplifier and switching applications. Drain and source interchangeable.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

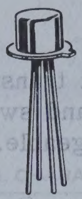
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Drain Current	I_D	3.0	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	50	-	-	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0) (V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)		I_{GSS}	- -	- -	0.1 100	nAdc
Gate-Source Cutoff Voltage (I_D = 0.1 nAdc, V_{DS} = 15 Vdc)	MFE2093 MFE2094 MFE2095	$V_{GS(off)}$	- - -	1.5 3.0 4.5	2.5 4.5 5.5	Vdc
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	MFE2093 MFE2094 MFE2095	I_{DSS}	0.1 0.4 1.0	0.35 0.7 1.5	0.7 1.4 3.0	mAdc
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)(1)	MFE2093 MFE2094 MFE2095	$\lvert y_{fs}\rvert$	250 350 400	400 500 600	500 700 800	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	MFE2093 MFE2094 MFE2095		150 250 300	- - -	- - -	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz) (1)	MFE2093 MFE2094 MFE2095	$\lvert y_{os}\rvert$	- - -	0.5 1.0 4.0	1.5 3.0 10.0	μmhos
Drain-Source Resistance (V_{DS} = 0, V_{GS} = 0)	MFE2093 MFE2094 MFE2095	$r_{ds(on)}$	- - -	2500 1600 1300	- - -	Ohms
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{iss}	-	4.0	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{rss}	-	1.2	2.0	pF

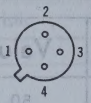
(1) Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

MFE3001 (SILICON)



Silicon N-channel insulated-gate field-effect transistor designed for low-power applications in the audio frequency range.

CASE 20
(TO-72)



STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND CASE LEAD

MAXIMUM RATINGS (T$_A$ = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation at T_A = 25°C Derating Factor above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

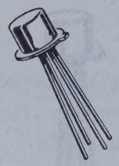
1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = -8 V, I_D = 10 μAdc)	BV_{DSX}	20	—	Vdc
Zero-Gate-Voltage Drain Current (V_{GS} = 0 Vdc, V_{DS} = 10 Vdc)	I_{DSS}	0.5	6.0	mAdc
Gate-Source Voltage Cutoff (I_{DS} = 1 μAdc, V_{DS} = 10 Vdc)	$V_{GS(off)}$	—	-8.0	Vdc
ON CHARACTERISTICS				
"On" Drain Current (V_{GS} = 3.5 Vdc, V_{DS} = 10 Vdc)	$I_{D(on)}$	5.0	—	mAdc
Gate-Reverse Current* (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}*	—	10	pAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	$\lvert y_{fs} \rvert$	700	3500	μmhos
Output Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	$\lvert y_{os} \rvert$	—	100	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	1.5	pF

*This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

MFE3002 (SILICON)



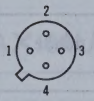
Active Elements Isolated From Case

Silicon N-channel MOS field-effect transistor designed for chopper applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

CASE 20
(TO-72)



STYLE 7
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND SUBSTRATE

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

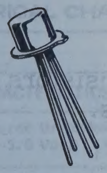
1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)
Substrate Connected to Source

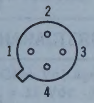
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = 10\ \mu Adc$)	BV_{DSS}	15	-	Vdc
Gate Leakage Current ($V_{GS} = 10$ Vdc, $V_{DS} = 0$)	I_{GSS}	-	100	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current ($V_{DS} = 10$ Vdc, $V_{GS} = 0$) ($V_{DS} = 10$ Vdc, $V_{GS} = 0$, $T_C = 125°C$)	I_{DSS}	- -	10 100	nAdc
Gate-Source Threshold Voltage ($V_{DS} = 10$ Vdc, $I_D = 10\ \mu Adc$)	$V_{GS(TH)}$	-	3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance ($V_{GS} = 10$ Vdc, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on)}$	-	100	Ohms
Drain-Substrate Capacitance ($V_{D(SUB)} = 10$ Vdc, f = 1.0 MHz)	$C_{d(sub)}$	-	4.0	pF
Input Capacitance ($V_{DS} = 10$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	-	1.0	pF

MFE3003 (SILICON)

Silicon P-channel MOS field-effect transistor designed for chopper applications.



CASE 20
(TO-72)



STYLE 7
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND SUBSTRATE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($V_{GS} = 0$, $I_D = -10\ \mu Adc$)	$V_{(BR)DSS}$	15	-	Vdc
Gate Leakage Current ($V_{GS} = \pm 10$ Vdc, $V_{DS} = 0$)	I_{GSS}	-	100	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current ($V_{DS} = -10$ Vdc, $V_{GS} = 0$) ($V_{DS} = -10$ Vdc, $V_{GS} = 0$, $T_C = 125°C$)	I_{DSS}	- -	10 100	nAdc
Gate-Source Threshold Voltage ($V_{DS} = -10$ Vdc, $I_D = -10\ \mu Adc$)	$V_{GS(TH)}$	-	4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance ($V_{GS} = -10$ Vdc, $I_D = 0$, f = 1.0 kHz)	$r_{ds(on)}$	-	200	Ohms
Drain-Substrate Capacitance ($V_{D(SUB)} = -10$ Vdc, f = 1.0 MHz)	$C_{d(sub)}$	-	4.0	pF
Input Capacitance ($V_{DS} = -10$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	-	1.0	pF

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

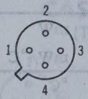
1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

MFE3004 (SILICON)
MFE3005

CASE 20
(TO-72)

Silicon N-channel MOS field-effect transistors designed for VHF/UHF amplifier applications.

Active Elements Isolated From Case



STYLE 7
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE AND SUBSTRATE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

HANDLING PRECAUTIONS:

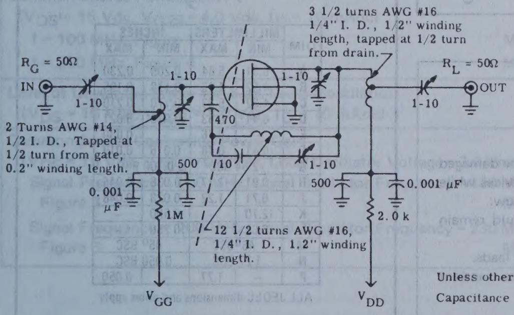
MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

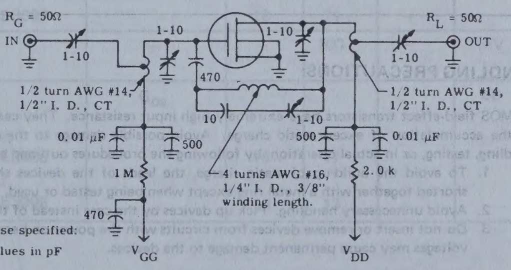
Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = -5.0 Vdc, I_D = 10 μAdc)	BV_{DSX}	20	-	Vdc
Gate-Source Cutoff Voltage (I_D = 10 μAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	-	5.0	Vdc
Gate Reverse Current (V_{GS} = ±15 Vdc, V_{DS} = 0)	I_{GSS}	-	50	pAdc
OFF CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	2.0	10	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	2000		μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	4.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	0.2	pF
Small-Signal Power Gain (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004 (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 650 ohms, f = 400 MHz) (Figure 2) MFE3005	G_{ps}	 16 10	 - -	dB
Noise Figure (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004 (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 650 ohms, f = 400 MHz) (Figure 2) MFE3005	NF	 - -	 4.5 4.5	dB

FIGURE 1 — 200 MHz TEST CIRCUIT NEUTRALIZED



R_G = 50Ω
IN
1-10
1-10
1-10
470
3 1/2 turns AWG #16 1/4" I. D., 1/2" winding length, tapped at 1/2 turn from drain.
R_L = 50Ω
OUT
1-10
2 Turns AWG #14, 1/2 I. D., Tapped at 1/2 turn from gate, 0.2" winding length.
500
10
1-10
500
0.001 μF
0.001 μF
1M
2.0 k
12 1/2 turns AWG #16, 1/4" I. D., 1.2" winding length.
V_{GG}
V_{DD}

FIGURE 2 — 400 MHz TEST CIRCUIT NEUTRALIZED



R_G = 50Ω
IN
1-10
1-10
1-10
470
R_L = 50Ω
OUT
1-10
1/2 turn AWG #14, 1/2" I. D., CT
10
1-10
1/2 turn AWG #14, 1/2" I. D., CT
0.01 μF
500
500
0.01 μF
1 M
4 turns AWG #16, 1/4" I. D., 3/8" winding length.
2.0 k
470
V_{GG}
V_{DD}

Unless otherwise specified:
Capacitance values in pF

MFE3006 (SILICON)
thru
MFE3008

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTORS

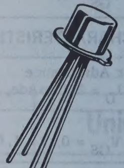
. . . depletion mode (Type B) dual gate transistors designed for VHF amplifier and mixer applications. These types are specified as follows:

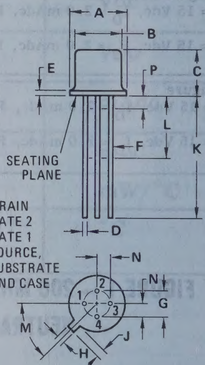
MFE3006 – RF Amplifier @ 100 MHz
MFE3007 – RF Amplifier @ 200 MHz
MFE3008 – Mixer @ 100 and 200 MHz

- Silicon Nitride Passivation for Excellent Long Term Stability
- High Common-Source Power Gain –
  MFE3006: G_{ps} = 20 dB (Min) @ f = 100 MHz
  MFE3007: G_{ps} = 18 dB (Min) @ f = 200 MHz
- High Common-Source Conversion Gain –
  MFE3008: G_{ps} = 14 dB (Min) @ f = 100 MHz
  G_{ps} = 10 dB (Min) @ f = 200 MHz
- Low Reverse Transfer Capacitance –
  C_{rss} = 0.02 pF (Typ) @ V_{DS} = 15 Vdc

N-CHANNEL DUAL GATE MOS FIELD-EFFECT TRANSISTORS

TYPE B





STYLE 9
PIN 1. DRAIN
2. GATE 2
3. GATE 1
4. SOURCE, SUBSTRATE AND CASE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+25	Vdc
Gate 1 Source Voltage	V_{G1S}	±35	Vdc
Gate 2 Source Voltage	V_{G2S}	±35	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 2.0	mW $mW/^oC$
Operating Junction Temperature Range	T_J	-65 to +175	^oC
Storage Temperature Range	T_{stg}	-65 to +175	^oC

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^oBSC		45^o BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

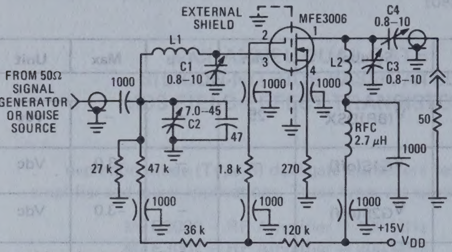
Substrate Connected to Source

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 10\ \mu$Adc, $V_S = 0$, $V_{G1} = V_{G2} = -4.0$ Vdc)	$V_{(BR)DSX}$	25	—	—	Vdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 200\ \mu$Adc)	$V_{G1S(off)}$	—	—	-3.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $V_{G1S} = 0$, $I_D = 200\ \mu$Adc)	$V_{G2S(off)}$	—	—	-3.0	Vdc
Gate 1 Reverse Leakage Current ($V_{G1S} = -10$ Vdc, $V_{G2S} = 0$, $V_{DS} = 0$) ($V_{G1S} = -35$ Vdc, $V_{G2S} = 0$, $V_{DS} = 0$)	I_{G1SS}	— —	— —	1.0 10	nAdc
Gate 2 Reverse Leakage Current ($V_{G2S} = -10$ Vdc, $V_{G1S} = 0$, $V_{DS} = 0$) ($V_{G2S} = -35$ Vdc, $V_{G1S} = 0$, $V_{DS} = 0$)	I_{G2SS}	— —	— —	1.0 10	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{G1S} = 0$, $V_{G2S} = 4.0$ Vdc) MFE3006 MFE3007 MFE3008	I_{DSS}	2.0 5.0 2.0	7.0 10 9.0	18 20 20	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (Gate 1 to Drain) ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz) MFE3006/8 MFE3007	Y_{fs}	8000 10,000	— —	18,000 18,000	µmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz) MFE3006/8 MFE3007	C_{iss}	— —	4.5 4.5	6.0 5.5	pF
Output Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz) MFE3006/8 MFE3007	C_{oss}	— —	2.5 2.5	4.0 3.5	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{rss}	—	0.02	—	pF
Common-Source Noise Figure ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, $R_S = 1000$ Ohms) f = 100 MHz, Figure 1 MFE3006 f = 200 MHz, Figure 4 MFE3007	NF	— —	2.5 3.0	4.0 4.0	dB
Common-Source Power Gain ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc) f = 100 MHz, Figure 1 MFE3006 f = 200 MHz, Figure 4 MFE3007	G_{ps}	20 18	25 21	— —	dB
Level of Unwanted Signal for 1.0% Cross Modulation ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc)	—	—	100	—	mV
Common-Source Conversion Power Gain ($V_{DS} = 15$ Vdc, $V_{G2S} = 0.5$ Vdc, Local Oscillator Voltage = 3.0 Vrms) Signal Frequency = 100 MHz, Local Oscillator Frequency = 130 MHz, Figure 3 MFE3008 Signal Frequency = 200 MHz, Local Oscillator Frequency = 230 MHz, Figure 6 MFE3008	G_{ps}	14 10	17 13	— —	dB

TEST CIRCUITS

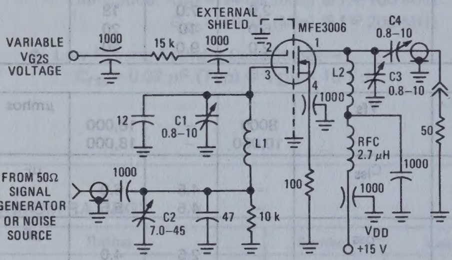
f = 100 MHz

FIGURE 1 – NOISE AND POWER GAIN


EXTERNAL SHIELD
MFE3006
C4 0.8–10
L1
C1 0.8–10
L2
C3 0.8–10
FROM 50Ω SIGNAL GENERATOR OR NOISE SOURCE
1000
7.0–45 C2
47
50
RFC 2.7 μH
27 k
47 k
1.8 k
270
36 k
120 k
+15 V
VDD

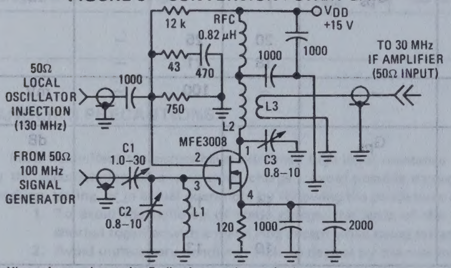
All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Centralab Type 825-G.N. or equivalent
L1: 5 Turns #16 AWG Wire (Internal diameter 5/16″, Length 5/8″)
L2: 5 Turns #16 AWG Wire (Internal diameter 3/8″, Length 5/8″)
Adjust C1, C2, C3 and C4 for maximum signal output; C1 and C2 for minimum noise figure, before measuring power gain.
Overall bandwidth = 3.0 MHz @ -3.0 dB
4.5 MHz @ -6.0 dB

FIGURE 2 – GAIN REDUCTION


VARIABLE VG2S VOLTAGE
1000
15 k
EXTERNAL SHIELD
MFE3006
C4 0.8–10
L2
C3 0.8–10
12
C1 0.8–10
L1
50
RFC 2.7 μH
FROM 50Ω SIGNAL GENERATOR OR NOISE SOURCE
C2 7.0–45
47
10 k
100
VDD
+15 V

All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Centralab Type 825-G.N. or equivalent
L1: 5 Turns #16 AWG Wire (Internal diameter 5/16″, Length 5/8″)
L2: 5 Turns #16 AWG Wire (Internal diameter 3/8″, Length 5/8″)
Overall bandwidth = 3.0 MHz @ -3.0 dB
4.5 MHz @ -6.0 dB

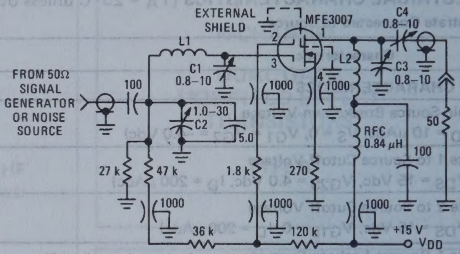
FIGURE 3 – CONVERSION POWER GAIN


VDD +15 V
12 k
RFC 0.82 μH
43
470
1000
TO 30 MHz IF AMPLIFIER (50Ω INPUT)
50Ω LOCAL OSCILLATOR INJECTION (130 MHz)
750
L2
L3
C1 1.0–30
MFE3008
C3 0.8–10
FROM 50Ω 100 MHz SIGNAL GENERATOR
C2 0.8–10
L1
120
2000

All capacitance values are in pF; all resistance values are in ohms.
L1: 6 Turns #16 AWG Wire (Internal diameter 5/16″, Length 7/16″)
L2: 25 Turns #32 AWG Wire wound on 1/4″ O.D. ceramic form
L3: 4 Turns #26 AWG Wire wound on top of and at dc supply end of L2
C1: Johanson Capacitor Type 3908 or equivalent
C2, C3: Johanson Capacitor Type 2950 or equivalent

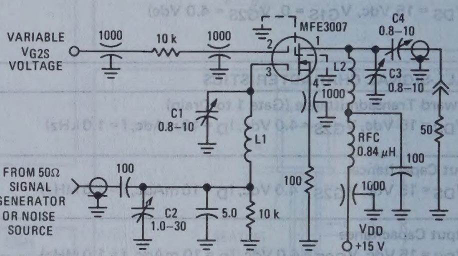
f = 200 MHz

FIGURE 4 – NOISE AND POWER GAIN


EXTERNAL SHIELD
MFE3007
C4 0.8–10
L1
C1 0.8–10
L2
C3 0.8–10
FROM 50Ω SIGNAL GENERATOR OR NOISE SOURCE
100
1.0–30 C2
5.0
1000
50
RFC 0.84 μH
100
27 k
47 k
1.8 k
270
36 k
120 k
+15 V
VDD

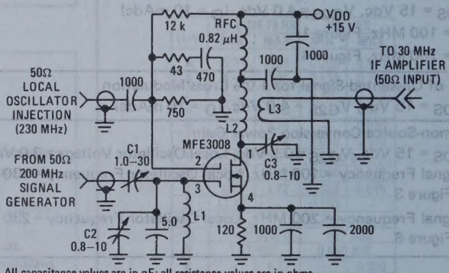
All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Johanson Type 3908 or equivalent
L1: 4 Turns #16 AWG Wire (Internal diameter 1/4″, Length 3/4″)
L2: 5 Turns #16 AWG Wire (Internal diameter 1/4″, Length 3/4″)
Adjust C1, C2, C3 and C4 for maximum signal output; C1 and C2 for minimum noise figure, before measuring power gain.
Overall bandwidth = 9.5 MHz @ -3.0 dB
14 MHz @ -6.0 dB

FIGURE 5 – GAIN REDUCTION


VARIABLE VG2S VOLTAGE
1000
10 k
MFE3007
C4 0.8–10
L2
C3 0.8–10
C1 0.8–10
L1
50
RFC 0.84 μH
100
FROM 50Ω SIGNAL GENERATOR OR NOISE SOURCE
C2 1.0–30
5.0
10 k
VDD
+15 V

All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Johanson Type 3908 or equivalent
L1: 4 Turns #16 AWG Wire (Internal diameter 1/4″, Length 3/4″)
L2: 5 Turns #16 AWG Wire (Internal diameter 1/4″, Length 3/4″)
Overall bandwidth = 9.5 MHz @ -3.0 dB
14 MHz @ -6.0 dB

FIGURE 6 – CONVERSION POWER GAIN


VDD +15 V
12 k
RFC 0.82 μH
43
470
1000
TO 30 MHz IF AMPLIFIER (50Ω INPUT)
50Ω LOCAL OSCILLATOR INJECTION (230 MHz)
750
L2
L3
C1 1.0–30
MFE3008
C3 0.8–10
FROM 50Ω 200 MHz SIGNAL GENERATOR
C2 0.8–10
5.0
L1
120
2000

All capacitance values are in pF; all resistance values are in ohms.
L1: 2 Turns #16 AWG Wire (Internal diameter 1/4″, Length 1/4″)
L2: 25 Turns #32 AWG Wire wound on 1/4″ O.D. ceramic form
L3: 4 Turns #26 AWG Wire wound on top of and at dc supply end of L2
C1: Johanson Capacitor Type 3908 or equivalent
C2, C3: Johanson Capacitor Type 2950 or equivalent

CIRCUIT PERFORMANCE

FIGURE 7 – POWER GAIN versus SOURCE RESISTANCE

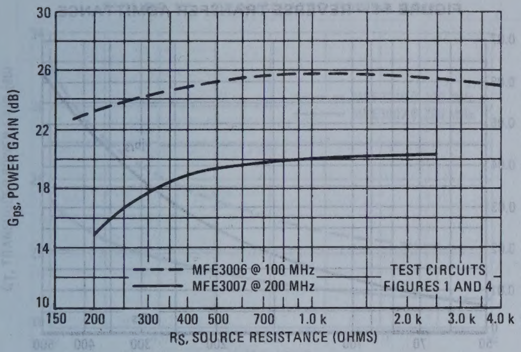


FIGURE 8 – NOISE FIGURE versus SOURCE RESISTANCE

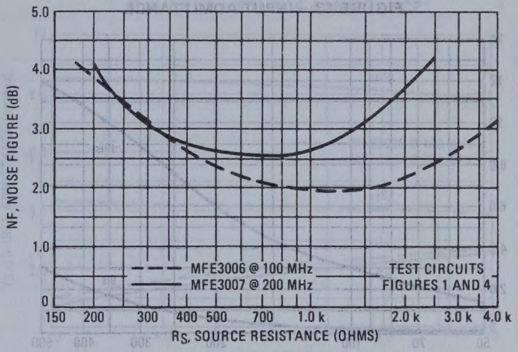


FIGURE 9 – GAIN REDUCTION

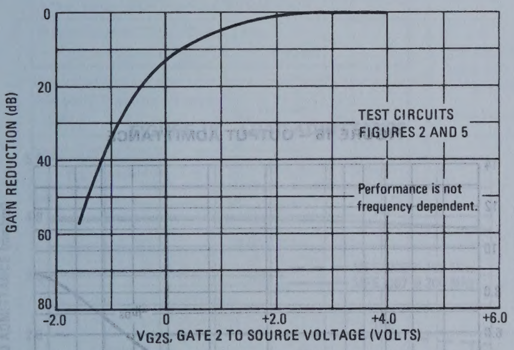


FIGURE 10 – COMMON SOURCE NOISE FIGURE versus GAIN REDUCTION

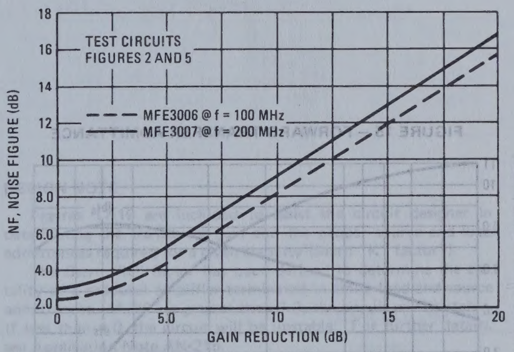


FIGURE 11 – CONVERSION POWER GAIN

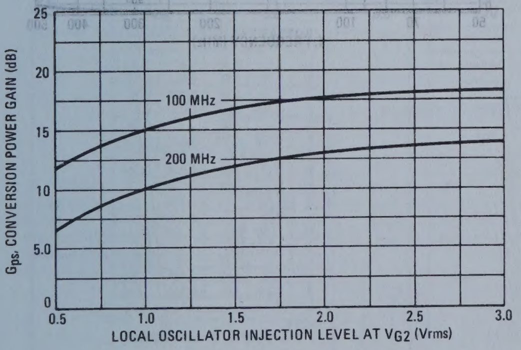
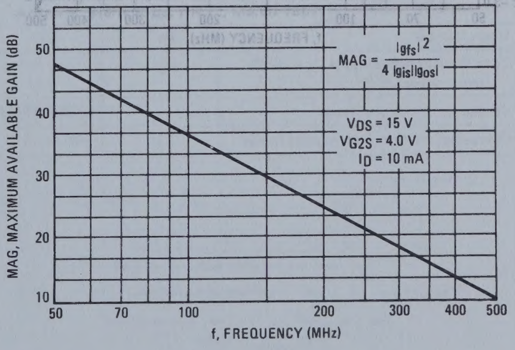


FIGURE 12 – MAXIMUM AVAILABLE POWER GAIN



COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 13 – INPUT ADMITTANCE

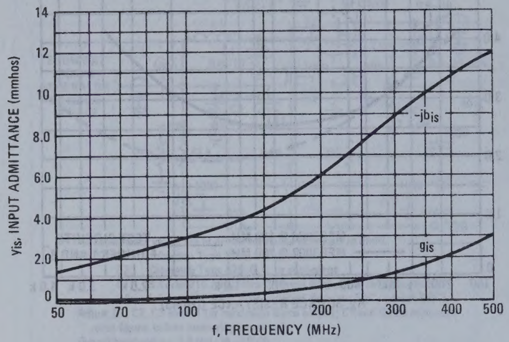


FIGURE 14 – REVERSE TRANSFER ADMITTANCE

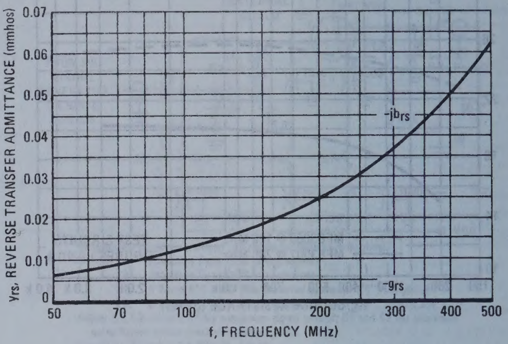


FIGURE 15 – FORWARD TRANSFER ADMITTANCE

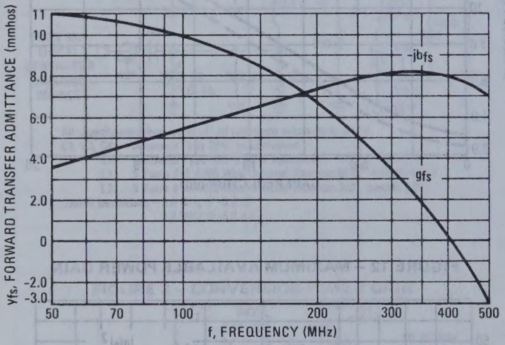
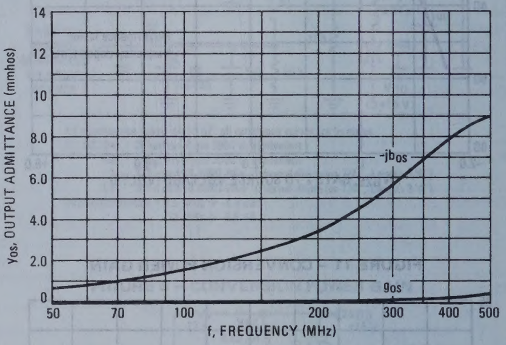


FIGURE 16 – OUTPUT ADMITTANCE



COMMON-SOURCE CIRCUIT DESIGN DATA AS A FUNCTION OF THE STERN "K" FACTOR

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 17 – TRANSDUCER POWER GAIN

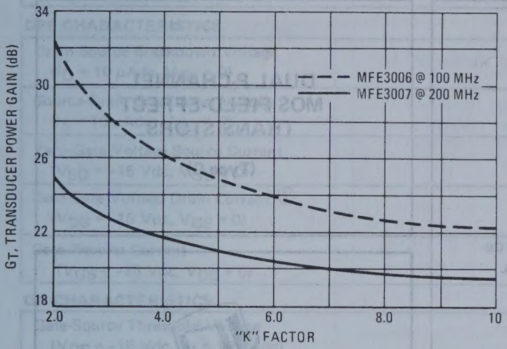


FIGURE 18 – SOURCE ADMITTANCE

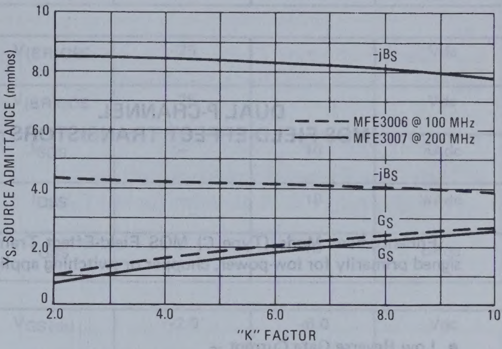
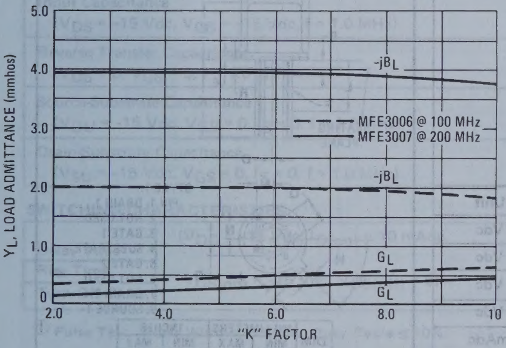


FIGURE 19 – LOAD ADMITTANCE



DESIGN NOTE

Figures 17-19 are included to assist the circuit designer in determining the transducer gain and the proper source and load admittances required for a given stability (Stern "K" factor*).

The Stern "K" factor has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

As the C_{rss} of the MFE3006-7 is comparable to the distributed capacitance of the circuit where it is used, a feedback capacitance of 0.1 pF has been used throughout these calculations.

*"Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

MFE3020 (SILICON)
MFE3021

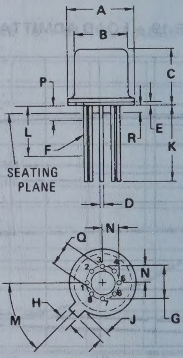
DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode (Type C) MOS Field-Effect Transistors designed primarily for low-power, chopper or switching applications.

- Low Reverse Gate Current — $I_{GSS} \leq 10$ pAdc @ $V_{GS} = -25$ Vdc
- Low Drain-Source "ON" Resistance — $r_{ds(on)} = 250$ Ohms (Max) @ $V_{GS} = -15$ Vdc (MFE3021)

DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

(Type C)



STYLE 1:
PIN 1. DRAIN 1
2. NOT USED
3. GATE 1
4. SUBSTRATE
5. GATE 2
6. NOT USED
7. DRAIN 2
8. SOURCE 1

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.737	1.14	0.029	0.045
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
Q	3.05	4.06	0.120	0.160
R	0.254	1.02	0.010	0.040

All JECEC dimensions and notes apply

NOTE:
1. DIM "Q" & "R" = STAND-OFF

CASE 642-02
(TO-76)

MAXIMUM RATINGS

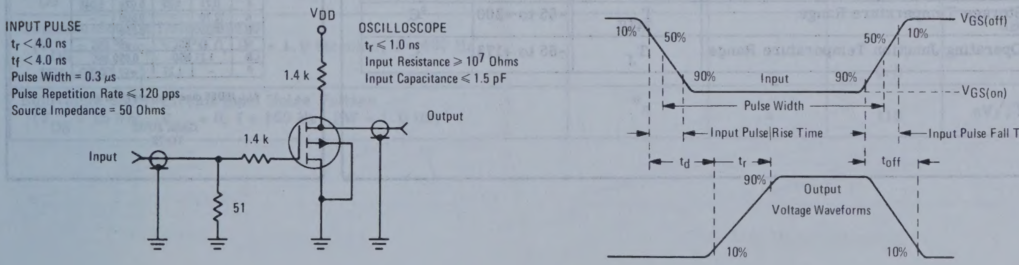
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	+25	Vdc
Forward Gate-Source Voltage	V_{GSF}	-25	Vdc
Drain Current	I_D	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 10\ \mu Adc$, $V_{GS} = 0$)	$V_{(BR)DSS}$	-25	–	Vdc
Source-Drain Breakdown Voltage ($I_S = 10\ \mu Adc$, $V_{GD} = 0$)	$V_{(BR)SDS}$	-25	–	Vdc
Zero-Gate Voltage Source Current ($V_{SD} = -15$ Vdc, $V_{GD} = 0$)	I_{SDS}	–	10	nAdc
Zero-Gate Voltage Drain Current ① ($V_{DS} = -15$ Vdc, $V_{GS} = 0$)	I_{DSS}	–	10	nAdc
Gate Reverse Current ($V_{GS} = -25$ Vdc, $V_{DS} = 0$)	I_{GSS}	–	10	pAdc
ON CHARACTERISTICS				
Gate-Source Threshold Voltage ($V_{DS} = -15$ Vdc, $I_D = 10\ \mu Adc$)	$V_{GS(th)}$	-2.0	-6.0	Vdc
"ON" Drain Current ($V_{DS} = -15$ Vdc, $V_{GS} = -15$ Vdc)	$I_{D(on)}$	10	75	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = -15$ Vdc, $I_D = 0$, f = 1.0 kHz) MFE3020 MFE3021	$r_{ds(on)}$	– –	500 250	Ohms
Forward Transadmittance ① ($V_{DS} = -15$ Vdc, $V_{GS} = -15$ Vdc, f = 1.0 kHz)	$\|y_{fs}\|$	500	–	µmhos
Input Capacitance ($V_{DS} = -15$ Vdc, $V_{GS} = -15$ Vdc, f = 1.0 MHz)	C_{iss}	–	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	–	1.5	pF
Source-Substrate Capacitance ($V_{DU} = -15$ Vdc, $V_{GS} = 0$, $I_S = 0$, f = 1.0 MHz)	C_{SU}	–	5.0	pF
Drain-Substrate Capacitance ($V_{SU} = -15$ Vdc, $V_{GS} = 0$, $I_S = 0$, f = 1.0 MHz)	C_{DU}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time ($V_{DD} = -15$ Vdc, $I_{D(on)} = 10$ mAdc, $V_{GS(on)} = -15$ Vdc, $V_{GS(off)} = 0$)	t_d	–	20	ns
Rise Time	t_r	–	30	ns
Turn-Off Time	t_{off}	–	50	ns

① Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

FIGURE 1 — SWITCHING TIMES CIRCUIT


INPUT PULSE
$t_r < 4.0$ ns
$t_f < 4.0$ ns
Pulse Width = 0.3 µs
Pulse Repetition Rate ≤ 120 pps
Source Impedance = 50 Ohms
Input
1.4 k
51
V_{DD}
1.4 k
OSCILLOSCOPE
$t_r \leq 1.0$ ns
Input Resistance ≥ 10^7 Ohms
Input Capacitance ≤ 1.5 pF
Output
$V_{GS(off)}$
10%
50%
90%
Input
90%
50%
10%
$V_{GS(on)}$
Pulse Width
Input Pulse Rise Time
Input Pulse Fall Time
t_d
t_r
t_{off}
90%
Output Voltage Waveforms
10%
10%

MFE4007 (SILICON)
thru
MFE4012

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type A) Field-Effect Transistors designed for general-purpose amplifier applications.

- Tightly Specified I_{DSS} Ranges – 2:1 for All Types
- High Gate-Source Breakdown Voltage – $V_{(BR)GSS}$ = 40 Vdc (Min) for All Types
- New Designers Data Sheet with Min/Max Curves for Ease in Design

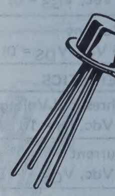
LIMIT DATA FOR "WORST CASE" DESIGNS

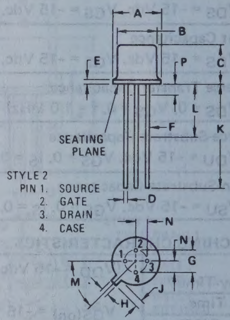
The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves – representing boundaries for device characteristics – are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.33	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc) MFE4007, MFE4008	$V_{GS(off)}$	-	3.0	Vdc
MFE4009, MFE4010		-	6.0	
MFE4011, MFE4012		-	8.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	I_{GSS}	-	2.0	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)		-	2.0	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0) MFE4007	I_{DSS}	0.5	1.0	mAdc
MFE4008		0.8	1.6	
MFE4009		1.5	3.0	
MFE4010		2.5	5.0	
MFE4011		4.0	8.0	
MFE4012		7.0	14	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc) MFE4007	V_{GS}	0.3	1.5	Vdc
(V_{DS} = 15 Vdc, I_D = 80 μAdc) MFE4008		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 150 μAdc) MFE4009		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 250 μAdc) MFE4010		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 400 μAdc) MFE4011		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 700 μAdc) MFE4012		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) MFE4007	$\|y_{fs}\|$	900	2700	μmhos
MFE4008		1000	3000	
MFE4009		1500	3500	
MFE4010		2000	4000	
MFE4011		2200	4500	
MFE4012		2500	5000	
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) MFE4007	$Re(y_{fs})$	800	-	μmhos
MFE4008		900	-	
MFE4009		1400	-	
MFE4010		1700	-	
MFE4011		1900	-	
MFE4012		2100	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)	NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)	e_n	-	115	nV/$\sqrt{\text{Hz}}$

TRANSFER CHARACTERISTIC CURVES FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

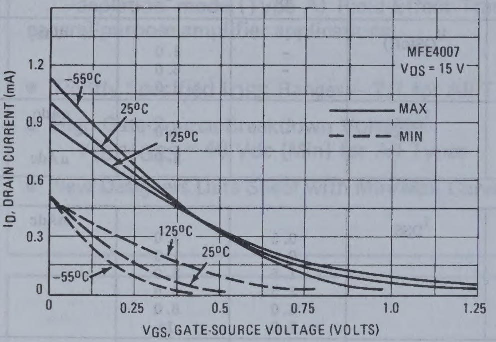


FIGURE 2

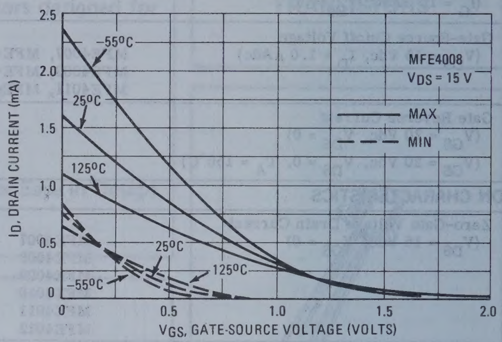


FIGURE 3

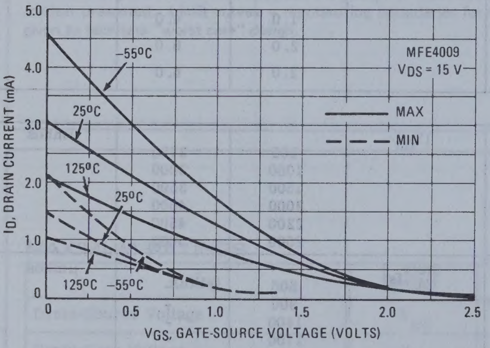


FIGURE 4

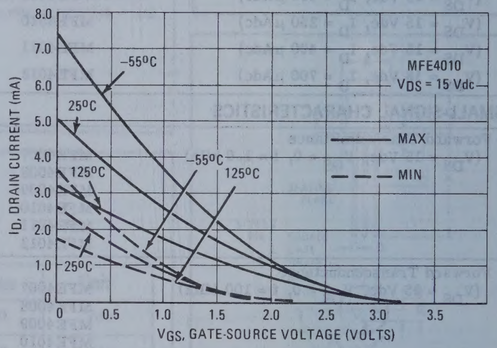


FIGURE 5

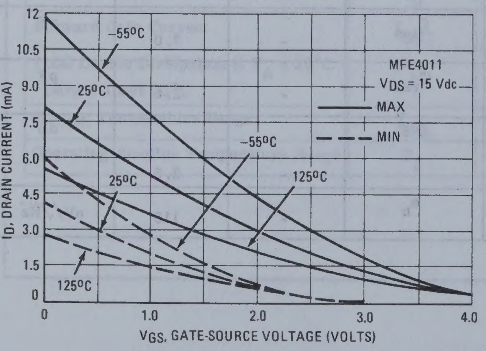
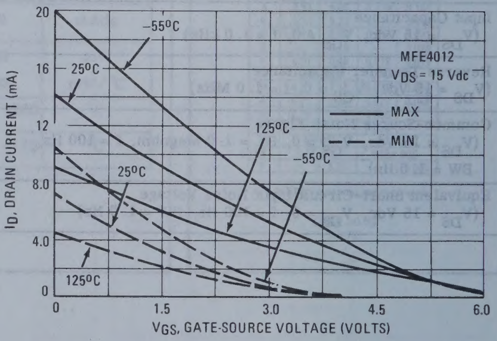


FIGURE 6



TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

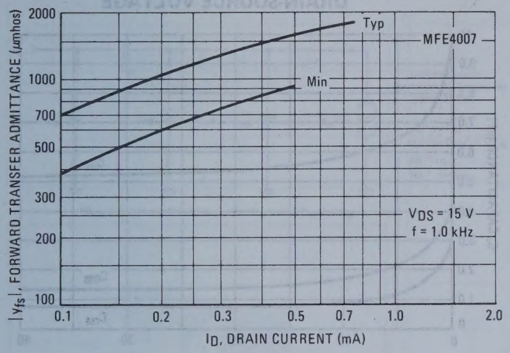


FIGURE 8

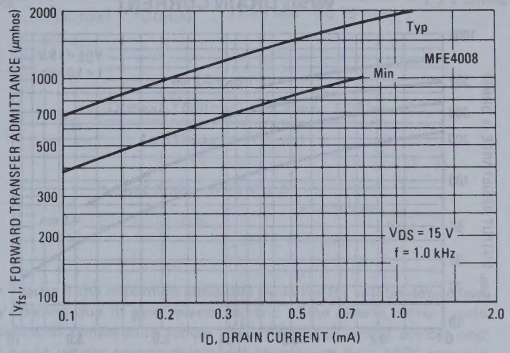


FIGURE 9

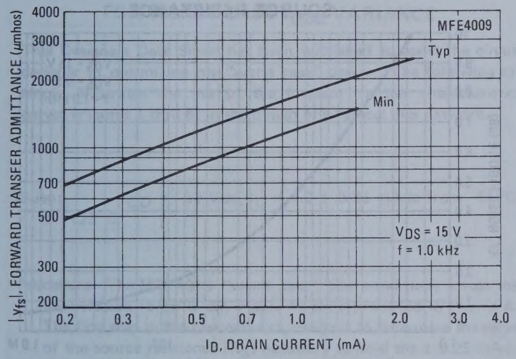


FIGURE 10

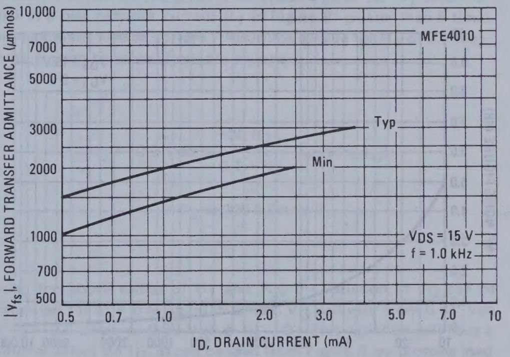


FIGURE 11

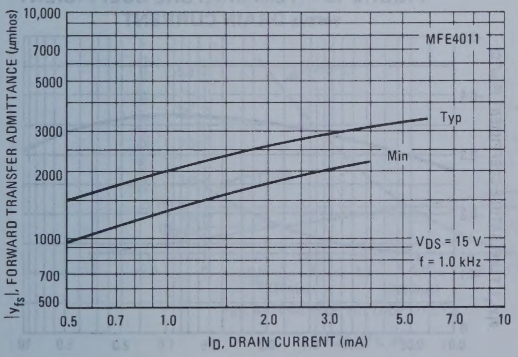
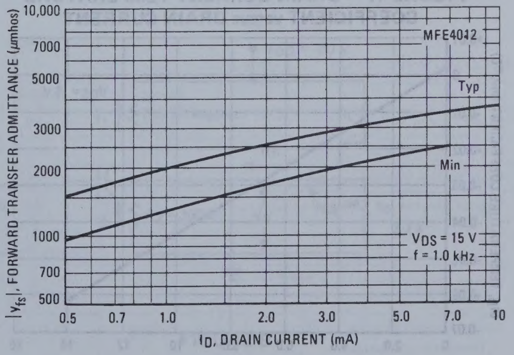


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

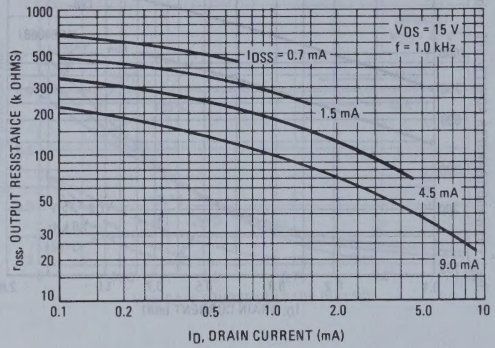


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

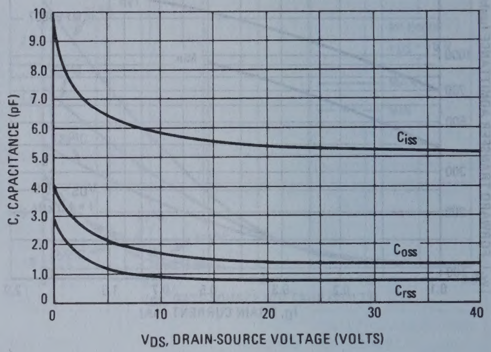


FIGURE 15 – NOISE FIGURE versus FREQUENCY

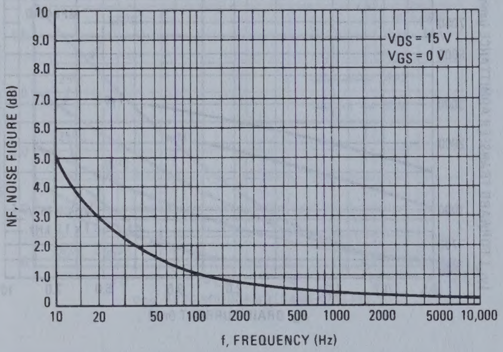


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

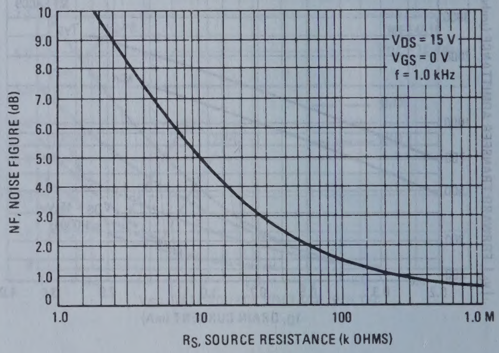


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

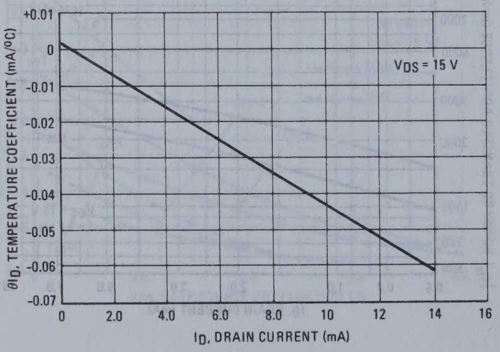


FIGURE 18 – TEMPERATURE COEFFICIENT versus DRAIN CURRENT

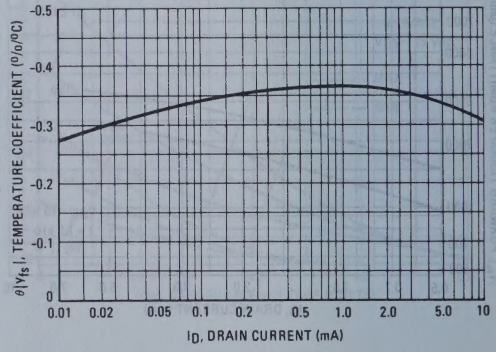
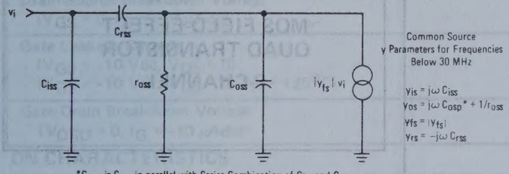


FIGURE 19 – EQUIVALENT LOW FREQUENCY CIRCUIT


v_i
C_{rss}
C_{iss}
r_{oss}
C_{oss}
$|y_{fs}|\,v_i$
Common Source
y Parameters for Frequencies
Below 30 MHz
$y_{is} = j\omega C_{iss}$
$y_{os} = j\omega C_{osp}^{*} + 1/r_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

BIAS NETWORK DESIGN FOR WORST CASE I_{DSS} VARIANCE

This Designers Data Sheet has been published to assist the circuit designer in optimizing his "worst case" design. The following example illustrates the use of the forward transfer characteristics curves (Figures 1 thru 6) in the design of a typical bias network.

Given: V_{DD} = -30 Vdc, I_D = 1.0 ± 0.25 mAdc from -55°C to +125°C

Procedure: The MFE4010 "worst case" bias conditions across the temperature range (from Figure 4) are reproduced in Figure A. The first step in the bias network design is to determine the value of the source resistance (R_S) necessary to hold the ± 0.25 mAdc I_D bias tolerance. To solve R_S, plot $I_{D(max)}$ and $I_{D(min)}$ on Figure A and calculate R_S, and V_G.

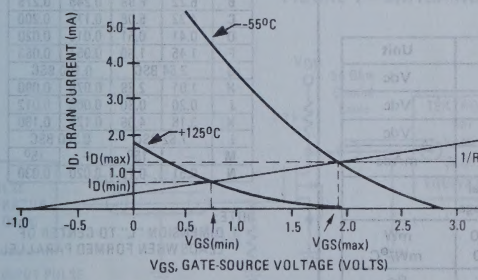


FIGURE A

$$R_S = \frac{V_{GS(max)} - V_{GS(min)}}{I_{D(max)} - I_{D(min)}} = \frac{1.9\text{ Vdc} - 0.8\text{ Vdc}}{(1.25\text{ mA} - 0.75\text{ mA})} = 2.2\text{ k Ohms}$$

$$V_G = \frac{I_{D(max)}\,V_{GS(min)} - I_{D(min)}\,V_{GS(max)}}{I_{D(max)} - I_{D(min)}}$$

$$= \frac{1.25 \times 0.80 - 0.75 \times 1.9}{0.5} = -0.9\text{ Vdc}$$

In Figure B the maximum allowable value for R_1 will be determined by loading due to gate reverse current. Gate reverse current variations with temperature follow the pattern of all silicon devices, and, as a rule, we can assume that it will double with each 15°C temperature rise. Therefore, we can assume a maximum reverse current of approximately 0.5 μAdc at 125°C, based on the specified maximum 2.0 μAdc reverse at 150°C. The variation in V_G bias versus temperature will not be too great if we chose a value for R_1 which results in a bias network current (I_1 in Figure B) greater than 5 times the maximum reverse current. Assuming a value for R_1 of 9.1 Megohms, R_2 can be solved from the equation:

$$V_G = -0.9\text{ Vdc} \approx \frac{-30\,R_2}{9.1 + R_2} \quad (\text{Ignoring } I_G)$$

$$R_2 \approx 300\text{ k Ohms}$$

Using the above values of R_1 and R_2, the variation in V_G can be computed for I_G = 0 to I_G = 0.5 μAdc. V_G will vary from 0.81 Vdc at I_G = 0.5 μAdc to 0.96 Vdc @ I_G = 0. This variation will have a minimal effect on I_D, as can be seen from Figure A by plotting load lines with a slope equal to $1/R_S$ from V_G = 0.81 Vdc and 0.96 Vdc respectively.

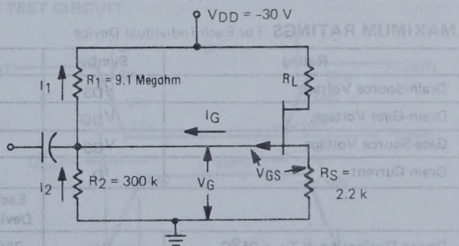


FIGURE B

MFE5000 (SILICON)

SILICON P-CHANNEL ENHANCEMENT MOS FIELD EFFECT QUAD TRANSISTOR

- Monolithic Construction Provides Improved Temperature Tracking
- Four Field Effect Transistors in One Package Cut Assembly Costs
- Diode Protected Gates
- Motorola's High Reliability Dual In-Line Ceramic Package

MOS FIELD-EFFECT QUAD TRANSISTOR

P-CHANNEL

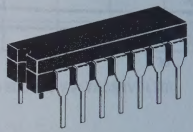
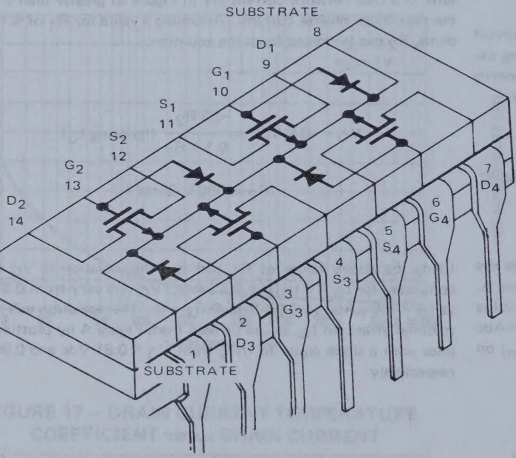
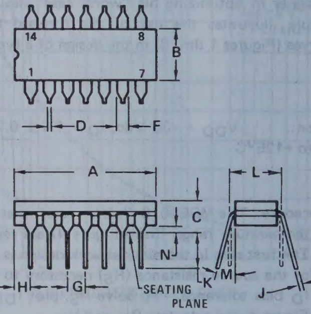


FIGURE 1 – SCHEMATIC DIAGRAM





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	19.05	19.81	0.750	0.780
B	6.22	6.99	0.245	0.275
C	4.32	5.08	0.170	0.200
D	0.41	0.51	0.016	0.020
F	1.45	1.60	0.057	0.063
G	2.54 BSC		0.100 BSC	
H	1.91	2.29	0.075	0.090
J	0.20	0.30	0.008	0.012
K	3.18	4.06	0.125	0.160
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030

NOTE:
1. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

CASE 632-03

MAXIMUM RATINGS For Each Individual Device

Rating	Symbol	Value		Unit
Drain-Source Voltage	V_{DS}	-25		Vdc
Drain-Gate Voltage	V_{DG}	±40		Vdc
Gate-Source Voltage	V_{GS}	±40		Vdc
Drain Current	I_D	50		mAdc
		Each Device	Total Package	
Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	250 1.66	450 3.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +175		°C

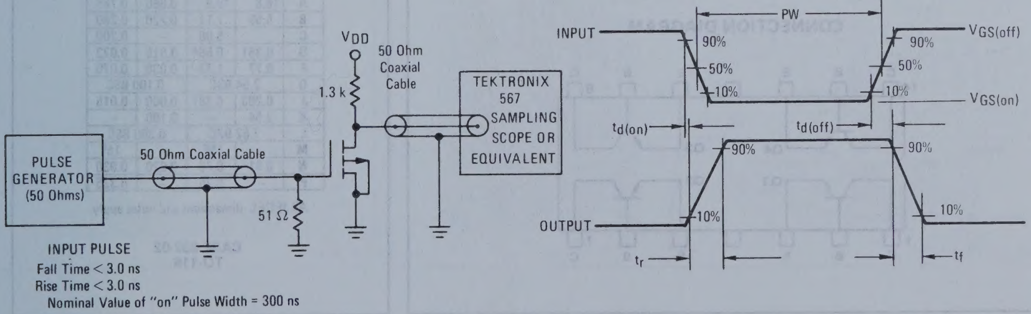
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) For Each FET

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = −10 μAdc)	$V_{(BR)DSS}$	25	–	–	Vdc
Gate Leakage Current (V_{GS} = −10 Vdc, V_{DS} = 0) (V_{GS} = −10 Vdc, V_{DS} = 0, T_A = 125°C)	I_{GSS}	– –	– –	1.0 1.0	nAdc μAdc
Gate-Drain Breakdown Voltage (V_{DSU} = 0, I_G = −10 μAdc)	$V_{(BR)GDS}$	50	100	125	Vdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = −10 Vdc), V_{GS} = 0) (V_{DS} = −10 Vdc, V_{GS} = 0, T_A = 125°C)	I_{DSS}	– –	1.0 1.0	10 10	nAdc μAdc
"ON" Drain Current (V_{DS} = −5.0 Vdc, V_{GS} = −10 Vdc)	$I_{D(on)}$	10	–	50	mAdc
Drain-Source "ON" Voltage (I_D = 5.0 mAdc, V_{GS} = −10 Vdc)	$V_{DS(on)}$	–	1.0	1.5	Vdc
Gate-Source Threshold Voltage (V_{DS} = −10 Vdc, I_D = −10 μAdc)	$V_{GS(th)}$	1.0	4.0	5.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = −10 Vdc, I_D = 0, f = 1.0 kHz) (V_{GS} = −25 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)1}$ $r_{ds(on)2}$	– –	175 75	225 110	Ohms
Input Capacitance (V_{DS} = −10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	5.0	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	0.6	2.0	pF
Forward Transfer Admittance (V_{DS} = −10 Vdc, V_{GS} = −10 Vdc, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	2000	5000	8000	μmhos
Output Admittance (V_{DS} = −10 Vdc, V_{GS} = −10 Vdc, f = 1.0 kHz)	$\lvert y_{os} \rvert$	–	400	1000	μmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Turn-On Delay Time	(V_{DD} = −15 Vdc, I_D = 10 mAdc, $V_{GS(on)}$ = 10 Vdc, $V_{GS(off)}$ = 0, See Figure 1)	$t_{d(on)}$	–	3.0	10	ns
Rise Time		t_r	–	10	20	ns
Turn-Off Delay Time		$t_{d(off)}$	–	5.0	10	ns
Fall Time		t_f	–	40	60	ns

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT


VDD
50 Ohm Coaxial Cable
1.3 k
TEKTRONIX 567 SAMPLING SCOPE OR EQUIVALENT
PULSE GENERATOR (50 Ohms)
50 Ohm Coaxial Cable
51 Ω
INPUT PULSE
Fall Time < 3.0 ns
Rise Time < 3.0 ns
Nominal Value of "on" Pulse Width = 300 ns
INPUT
PW
90%
50%
10%
VGS(off)
VGS(on)
td(on)
td(off)
90%
10%
OUTPUT
tr
tf

MHQ918 (SILICON)

QUAD DUAL IN-LINE
NPN SILICON HERMETIC ANNULAR
HIGH FREQUENCY AMPLIFIER TRANSISTORS

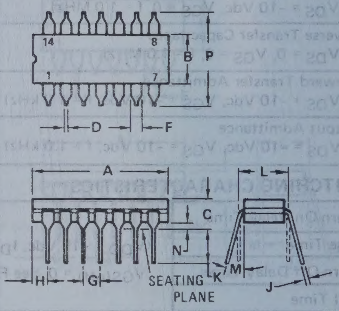
. . . designed for low-level, high-gain amplifier applications.

- Low Noise Figure — @ I_C = 1.0 mAdc
  NF = 4.0 dB (Typ)
- High Current-Gain—Bandwidth Product —
  f_T = 850 MHz (Typ) @ I_C = 4.0 mAdc
- Transistors Similar to 2N918
- TO-116 Ceramic Package — Compact Size, Compatible with IC Automatic Insertion Equipment

QUAD DUAL IN-LINE NPN SILICON HIGH FREQUENCY AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.65 3.72	1.9 10.88	Watts mW/^oC
Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.3 7.43	4.6 26.3	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

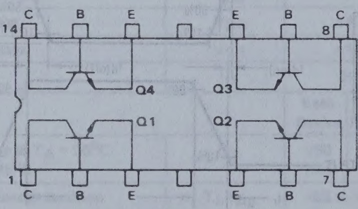


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15^0	–	15^0
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

CASE 632-02
TO-116

CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		–	110	–	
(I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)		20	80	–	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		–	50	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.11	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.84	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	850	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	0.75	2.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	1.4	2.5	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 Ohms, f = 60 MHz)	NF	–	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MHQ2221, MHQ2222 (SILICON)
MPQ2221, MPQ2222

QUAD DUAL-IN-LINE NPN SILICON ANNULAR GENERAL-PURPOSE TRANSISTORS

. . . Designed for general-purpose switching circuits and DC to VHF amplifier applications.

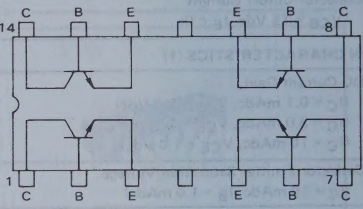
- Choice of Ceramic or Plastic Package
- DC Current Gain Specified — 10 to 300 mAdc
- Low Collector-Cutoff Current — I_{CBO} = 50 nAdc (Max) @ V_{CB} = 50 Vdc
- High Collector Breakdown Voltages — BV_{CEO} = 40 Vdc (Min) BV_{CBO} = 60 Vdc (Min)
- Transistors Similar to 2N2218 thru 2N2222 Series
- TO-116 Packaging — Compact Size Compatible With IC Automatic Insertion Equipment
- MHQ2221 Available With BV_{CEO} = 60 Vdc on Specified Request

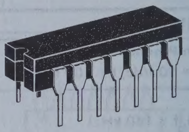
QUAD DUAL-IN-LINE
NPN SILICON
GENERAL-PURPOSE
TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Total Power Dissipation @ $T_A = 25^oC$	P_D	0.65	1.9	Watts
Derate above 25°C MHQ2221, MHQ2222 MPQ2221, MPQ2222		3.72 5.2	10.88 15.2	mW/°C
Operating and Storage Junction Temperature Range MHQ2221,22 MPQ2221,22	T_J, T_{stg}	-65 to +200 -55 to +150		°C

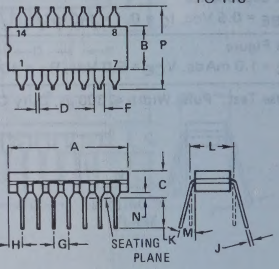
CONNECTION DIAGRAM





MHQ2221, MHQ2222

CERAMIC
CASE 632-02
TO-116

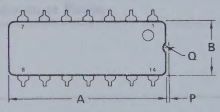


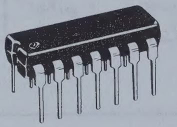
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:

DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

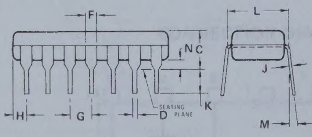




MPQ2221, MPQ2222

CASE 646

PLASTIC PACKAGE



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ2221, MPQ2221		35	–	–	
	MHQ2222, MPQ2222		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ2221, MPQ2221		40	–	–	
	MHQ2222, MPQ2222		100	–	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ2221, MPQ2221		20	–	–	
	MHQ2222, MPQ2222		30	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	4.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	17	30	pF
SWITCHING CHARACTERISTICS (Figure 1)						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)		t_{on}	–	25	–	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)		t_{off}	–	250	–	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

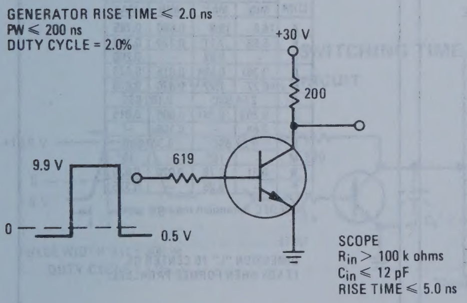
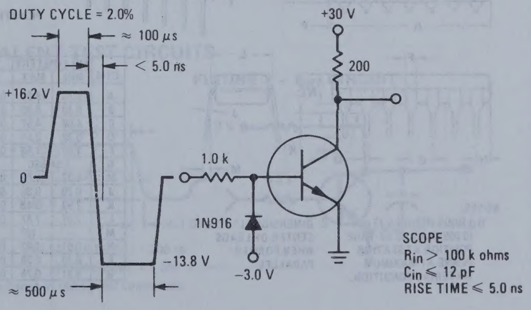

GENERATOR RISE TIME ≤ 2.0 ns
PW ≤ 200 ns
DUTY CYCLE = 2.0%
+30 V
200
9.9 V
619
0
0.5 V
SCOPE
R_{in} > 100 k ohms
C_{in} ≤ 12 pF
RISE TIME ≤ 5.0 ns

FIGURE 2 — STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT


DUTY CYCLE = 2.0%
≈ 100 μs
< 5.0 ns
+16.2 V
0
−13.8 V
≈ 500 μs
+30 V
200
1.0 k
1N916
−3.0 V
SCOPE
R_{in} > 100 k ohms
C_{in} ≤ 12 pF
RISE TIME ≤ 5.0 ns

MHQ2369 (SILICON)
MPQ2369

QUAD DUAL-IN-LINE NPN SILICON ANNULAR SWITCHING TRANSISTORS

. . . designed for low-current, high-speed switching and space saving applications.

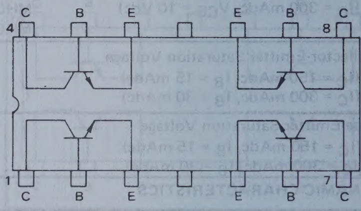
- Choice of Ceramic or Plastic Package
- High Current-Gain—Bandwidth Product —
  f_T = 550 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Times — @ V_{CC} = 3.0 Vdc
  t_{on} = 9.0 ns (Typ)
  t_{off} = 15 ns (Typ)
- Low Saturation Voltage —
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Each Transistor Similar to 2N2369
- TO-116 Package — Compact Size Compatible With IC Automatic Insertion Equipment

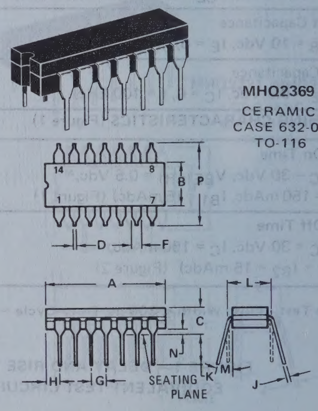
QUAD DUAL-IN-LINE NPN SILICON SWITCHING TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current — Peak	I_C	500		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ T_A = 25°C	P_D	0.5	1.5	Watts
Derate above 25°C MHQ2369		2.86	8.58	mW/°C
MPQ2369		4.0	12	
Operating and Storage Junction Temperature Range MHQ2369	T_J, T_{stg}	-65 to +200		°C
MPQ2369		-55 to +150		

CONNECTION DIAGRAM



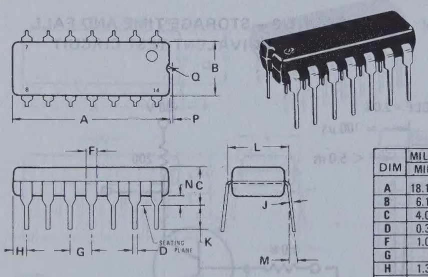


MHQ2369
CERAMIC
CASE 632-02
TO-116

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.



MPQ2369
CASE 646
PLASTIC PACKAGE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	4.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	0.4	µAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.5	µAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20	 – –	 – –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	450	550	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	2.5	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	3.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	9.0	–	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	–	15	–	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle = 2%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – t_{on} CIRCUIT

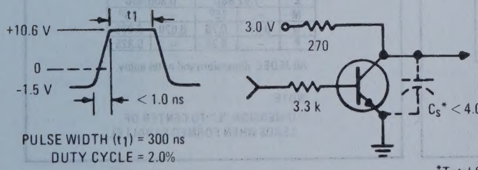
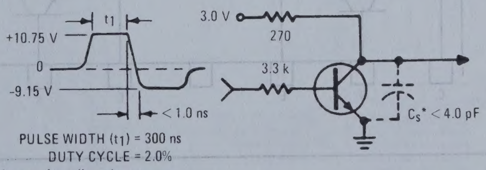

t1
+10.6 V
0
-1.5 V
< 1.0 ns
3.0 V
270
3.3 k
Cs* < 4.0 pF
PULSE WIDTH (t1) = 300 ns
DUTY CYCLE = 2.0%

FIGURE 2 – t_{off} CIRCUIT


t1
+10.75 V
0
-9.15 V
< 1.0 ns
3.0 V
270
3.3 k
Cs* < 4.0 pF
PULSE WIDTH (t1) = 300 ns
DUTY CYCLE = 2.0%

*Total Shunt Capacitance of test jig and connectors.

MHQ2483 (SILICON)
MHQ2484

QUAD DUAL-IN-LINE NPN HERMETIC SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for low-level, high-gain amplifier applications.

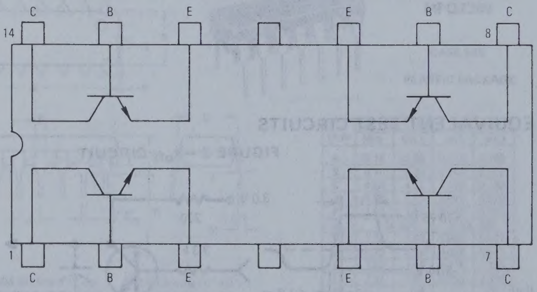
- Low Noise Figure – @ I_C = 10 μAdc, f = 10 Hz to 15.7 kHz
  NF = 3.0 dB (Typ) – MHQ2483
  = 2.0 dB (Typ) – MHQ2484
- Transistors Similar to 2N2483 and 2N2484
- TO-116 Ceramic Package – Compact Size Compatible with I_C Automatic Insertion Equipment

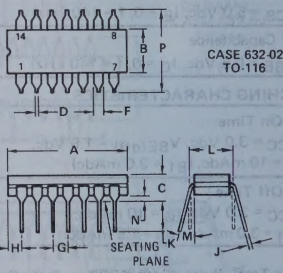
QUAD DUAL-IN-LINE NPN SILICON AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.42	1.8 10.3	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	4.2 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

CONNECTION DIAGRAM





CASE 632-02
TO-116

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:

DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage[1] (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	—	—	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain[1]		h_{FE}				—
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MHQ2483 MHQ2484		100 200	— —	— —	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MHQ2483 MHQ2484		150 300	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ2483 MHQ2484		150 300	— —	— —	
Collector-Emitter Saturation Voltage[1] (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	 — —	 0.13 0.15	 0.35 0.5	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	 — —	 0.58 0.70	 0.7 0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	100	—	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	1.8	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	4.0	8.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	 MHQ2483 MHQ2484	NF	 — —	 3.0 2.0	 — —	dB

MHQ2906, MHQ2907 (SILICON)
MPQ2906, MPQ2907

QUAD DUAL-IN-LINE PNP SILICON ANNULAR GENERAL-PURPOSE TRANSISTORS

. . . designed for general-purpose switching circuits and DC to VHF amplifier applications.

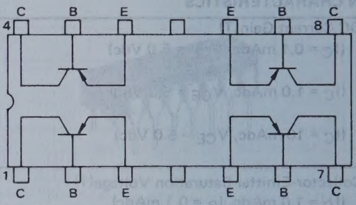
- Choice of Ceramic or Plastic Package
- High Collector-Base Breakdown Voltage — BV_{CBO} = 60 Vdc (Min) @ I_C = 10 μAdc
- DC Current Gain Specified — 10 to 300 mAdc
- High Current-Gain—Bandwidth Product — f_T = 350 MHz (Typ) @ I_C = 50 mAdc
- Transistors Similar to 2N2906 and 2N2907
- TO-116 Packaging — Compact Size Compatible With IC Automatic Insertion Equipment

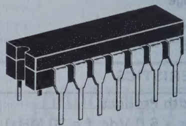
QUAD DUAL-IN-LINE PNP SILICON GENERAL-PURPOSE TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25^oC$	P_D	0.65	1.9	Watts
Derate above 25°C MHQ2906, MHQ2907		3.72	10.88	mW/°C
MPQ2906, MPQ2907		5.2	15.2	
Operating and Storage Junction Temperature Range MHQ2906,07	T_J,T_{stg}	-65 to +200		°C
MPQ2906,07		-55 to +150		

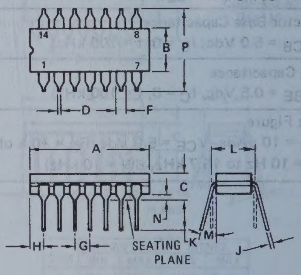
CONNECTION DIAGRAM





MHQ2906, MHQ2907

CERAMIC
CASE 632-02
TO-116

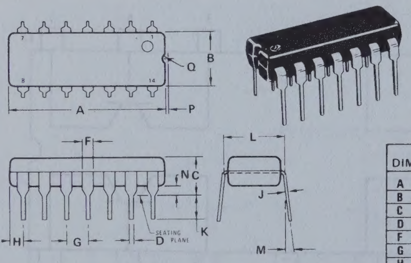


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:

DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.



MPQ2906, MPQ2907

CASE 646

PLASTIC PACKAGE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

NOTES:

1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		35	—	—	
	MHQ2907, MPQ2907		75	—	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		40	—	—	
	MHQ2907, MPQ2907		100	—	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ2906, MPQ2906		30	—	—	
	MHQ2907, MPQ2907		50	—	—	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	1.6	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	—	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			—	—	2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	6.0	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	20	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)		t_{on}	—	30	—	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)		t_{off}	—	100	—	ns

(1) **Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.**

FIGURE 1 – DELAY AND RISE TIME TEST CIRCUIT

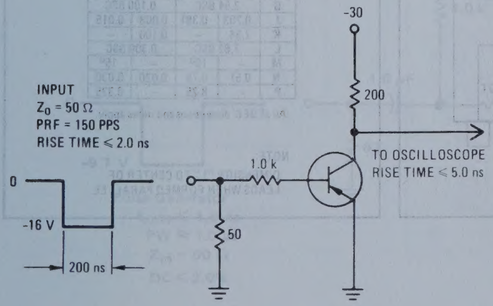
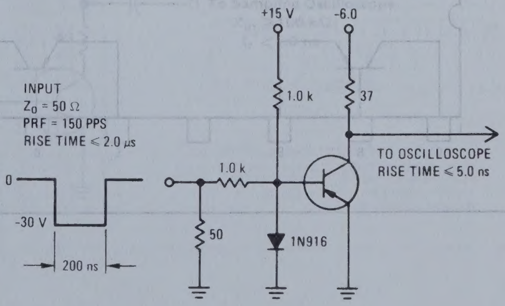

-30
INPUT
Z0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 ns
200
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns
1.0 k
0
-16 V
50
200 ns

FIGURE 2 – STORAGE AND FALL TIME TEST CIRCUIT


+15 V
-6.0
INPUT
Z0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 μs
1.0 k
37
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns
1.0 k
0
-30 V
50
1N916
200 ns

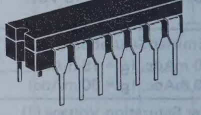
MHQ3467 (SILICON)

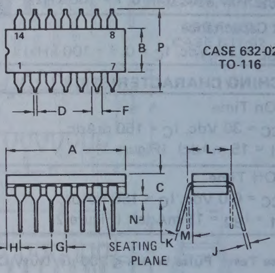
QUAD DUAL-IN-LINE PNP HERMETIC SILICON ANNULAR MEMORY DRIVER TRANSISTORS

. . . designed for medium-current, high-speed switching, ferrite core and plated wire memory driver, and MOS translator applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 500 mAdc
- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Transistors Similar to 2N3467
- TO-116 Ceramic Package — Compact Size Compatible With IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE PNP SILICON MEMORY DRIVER TRANSISTORS





CASE 632-02
TO-116

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

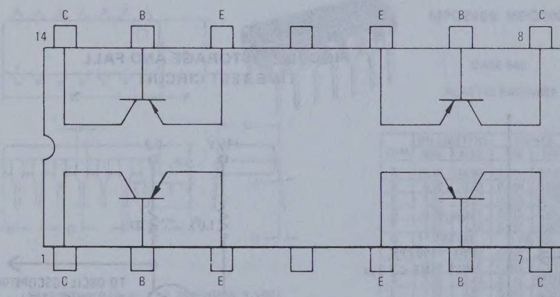
All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Total Device	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.9 5.14	2.7 15.4	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	6.3 36	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		°C

CONNECTION DIAGRAM

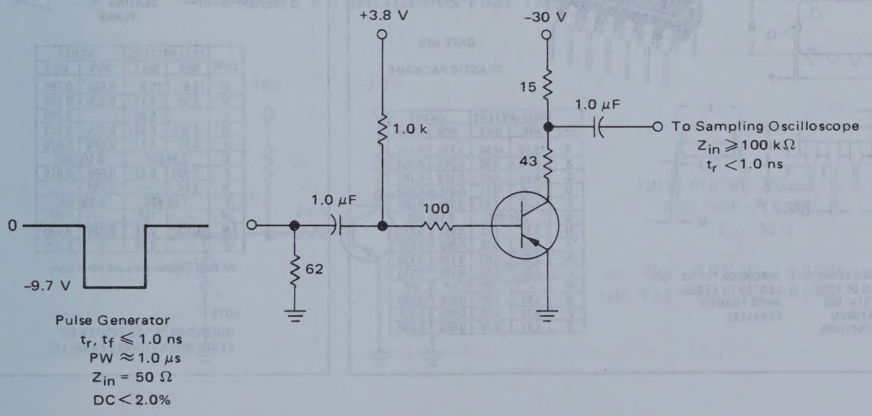


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	200	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	200	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.23	0.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	–	0.9	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain — Bandwidth Products (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	190	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	55	80	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	–	–	40	ns
Turn-Off Time (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	–	90	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT


+3.8 V
-30 V
15
1.0 μF
To Sampling Oscilloscope
$Z_{in} \geq 100\ k\Omega$
$t_r < 1.0$ ns
1.0 k
43
1.0 μF
100
0
-9.7 V
62
Pulse Generator
$t_r, t_f \leq 1.0$ ns
PW ≈ 1.0 μs
Z_{in} = 50 Ω
DC < 2.0%

MHQ3546 (SILICON)
MPQ3546

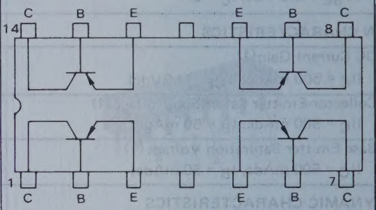
QUAD DUAL-IN-LINE PNP SILICON ANNULAR SWITCHING TRANSISTORS

. . . designed for low-level, high-speed switching applications.

- Choice of Ceramic or Plastic Package
- High Current-Gain—Bandwidth Product — f_T = 1000 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Times
  t_{on} = 15 ns (Typ)
  t_{off} = 25 ns (Typ)
- Transistor Similar to 2N3546
- TO-116 Packaging — Compact Size Compatible With IC Automatic Insertion Equipment

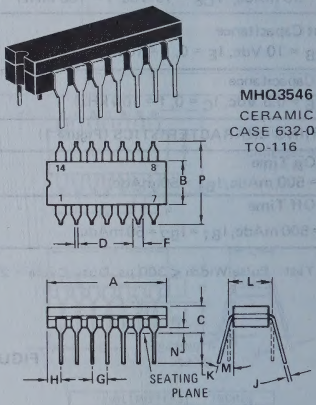
QUAD DUAL-IN-LINE PNP SILICON SWITCHING TRANSISTOR

CONNECTION DIAGRAM



MAXIMUM RATINGS

Rating		Symbol	Value		Unit
Collector-Emitter Voltage		V_{CEO}	12		Vdc
Collector-Base Voltage		V_{CB}	15		Vdc
Emitter-Base Voltage		V_{EB}	4.5		Vdc
Collector Current — Continuous		I_C	200		mAdc
			Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25^oC$		P_D	0.5	1.5	Watts
Derate above 25°C	MHQ3546		2.86	8.58	mW/°C
	MPQ3546		4.0	12	
Operating and Storage Junction Temperature Range	MHQ3546	T_J,T_{stg}	-65 to +200		°C
	MPQ3546		-55 to +150		

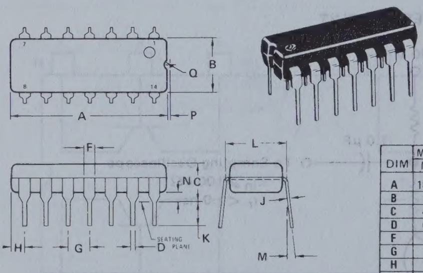


MHQ3546
CERAMIC
CASE 632-02
TO-116

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.



MPQ3546

CASE 646

PLASTIC PACKAGE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

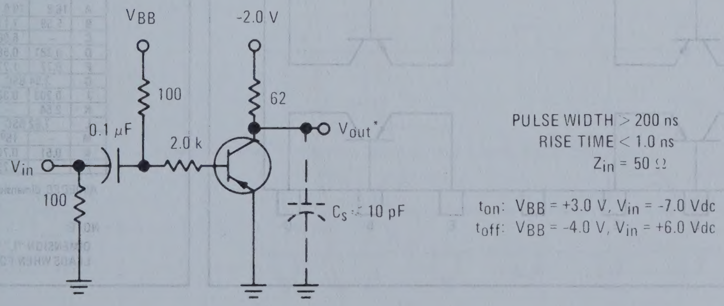
NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	–	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		15	–	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product(1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1000	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	3.5	8.0	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (V_{CC} = 2.0 Vdc, $V_{BE(off)}$ = 3.0 Vdc, I_C = 30 mAdc, I_{B1} = 1.5 mAdc)	t_{on}	–	15	–	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc)	t_{off}	–	25	–	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



*Oscilloscope Rise Time < 1.0 ns

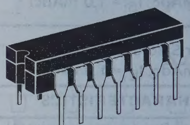
MHQ3798 (SILICON)
MHQ3799

QUAD DUAL-IN-LINE PNP HERMETIC SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for low-level, low-noise amplifier applications.

- Low DC Current Gain Specified – 10 μAdc to 10 mAdc
  h_{FE} = 150 (Min) @ I_C = 500 μAdc – MHQ3798
  = 300 (Min) @ I_C = 500 μAdc – MHQ3799
- Low Capacitance –
  C_{ob} = 2.3 pF (Typ) @ V_{CB} = 5.0 Vdc
- Low Noise Figure – NF = 2.5 dB (Typ) @ I_C = 100 μAdc
- Transistors Similar to 2N3798 and 2N3799
- TO-116 Ceramic Packaging – Compact Size Compatible With IC Automatic Insertion Equipment

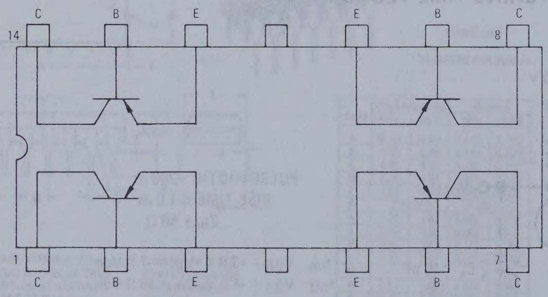
QUAD DUAL-IN-LINE PNP SILICON AMPLIFIER TRANSISTORS

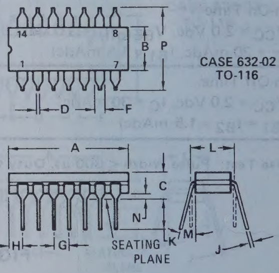


MAXIMUM RATINGS

Rating	Symbol	MHQ3798	MHQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.5 2.86	1.5 8.58	Watts mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 5.71	3.5 20	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

CONNECTION DIAGRAM





CASE 632-02
TO-116

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15^0	–	15^0
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:

DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MHQ3798 MHQ3799	BV_{CEO}	40 60	— —	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799	h_{FE}	100 225	— —	— —	—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799		150 300	— —	— —	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799		150 300	— —	— —	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ3798 MHQ3799		125 250	— —	— —	
Collector-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100μ Adc)		$V_{CE(sat)}$	 — —	 — —	 0.2 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	 — —	 — —	 0.7 0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	—	130	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	2.3	—	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	5.5	—	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k Ohms, f = 10 Hz to 15.7 kHz)	MHQ3798 MHQ3799	NF	— —	2.5 1.5	— —	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

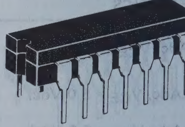
MHQ4001A (SILICON)
MHQ4002A

QUAD DUAL-IN-LINE NPN HERMETIC SILICON ANNULAR MEMORY DRIVER TRANSISTORS

. . . designed for high current, high speed switching, ferrite core and plated wire memory driver, and MOS translator applications.

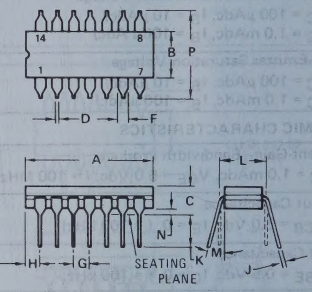
- Fast Switching Times —
  t_{on} = 40 ns (Max)
  t_{off} = 75 ns (Max)
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.95 Vdc (Max) @ I_C = 1.0 Adc
- DC Current Gain Specified —
  100 mAdc to 1.0 Adc
- Transistors Similar to 2N3725
- TO-116 Ceramic Package — Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE NPN SILICON MEMORY DRIVER TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MHQ 4001A	MHQ 4002A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CB}	60	70	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		°C



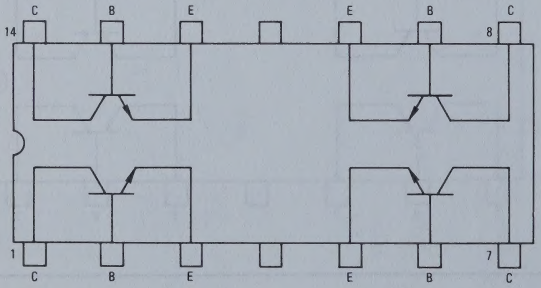
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

CASE 632-02
TO-116

All JEDEC dimensions and notes apply.

CONNECTION DIAGRAM

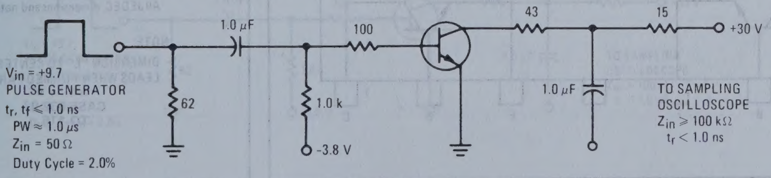


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0) MHQ4001A MHQ4002A	BV_{CEO}	40 45	– –	– –	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 µAdc, V_{BE} = 0) MHQ4001A MHQ4002A	BV_{CES}	60 70	– –	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0) MHQ4001A MHQ4002A	BV_{CBO}	60 70	– –	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	500	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	50 30 20	100 60 45	250 – –	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	– – –	0.14 0.23 0.36	0.26 0.52 0.95	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	– 0.8 –	0.75 0.88 1.0	0.86 1.1 1.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	275	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	5.0	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	55	70	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 0.5 Adc, $V_{BE(off)}$ = 3.8 Vdc, I_{B1} = 50 mAdc)	t_{on}	–	30	40	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 0.5 Adc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	60	75	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



MHQ4013 (SILICON)
MHQ4014

QUAD DUAL-IN-LINE NPN HERMETIC SILICON ANNULAR MEMORY DRIVER TRANSISTORS

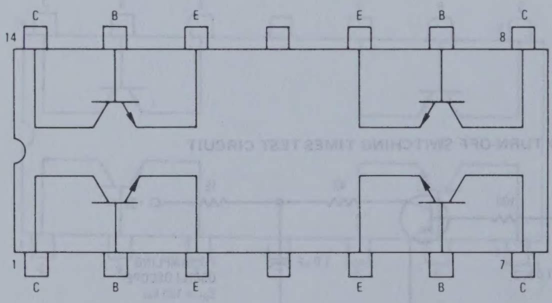
. . . designed for high current, high speed switching, ferrite core and plated wire memory driver, and MOS translator applications.

- Fast Switching Times –
  t_{on} = 35 ns (Max)
  t_{off} = 60 ns (Max)
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.95 Vdc (Max) @ I_C = 1.0 Adc
- DC Current Gain Specified –
  100 mAdc to 1.0 Adc
- Transistors Similar to 2N3725
- TO-116 Ceramic Package – Compact Size Compatible with IC Automatic Insertion Equipment

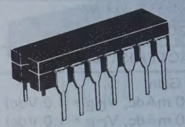
MAXIMUM RATINGS

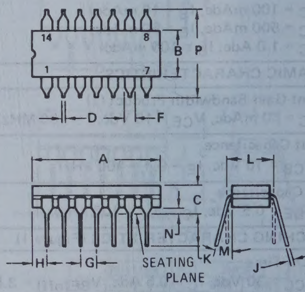
Rating	Symbol	MHQ4013	MHQ4014	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Collector-Base Voltage	V_{CB}	60	70	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	750 4.3	2500 14.3	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		°C

CONNECTION DIAGRAM



QUAD DUAL-IN-LINE NPN SILICON MEMORY DRIVER TRANSISTORS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15°	–	15°
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:

DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

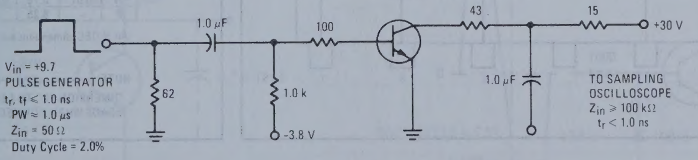
CASE 632-02
TO-116

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MHQ4013	BV_{CEO}	40	–	–	Vdc
	MHQ4014		45	–	–	
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	MHQ4013	BV_{CES}	60	–	–	Vdc
	MHQ4014		70	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MHQ4013	BV_{CBO}	60	–	–	Vdc
	MHQ4014		70	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0		–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	500	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			60	100	250	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			35	65	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			25	50	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	0.14	0.26	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.23	0.52	
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	0.36	0.95	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	0.75	0.86	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	0.88	1.1	
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	1.0	1.7	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	275	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	5.0	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	50	70	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, I_C = 0.5 Adc, $V_{BE(off)}$ = 3.8 Vdc, I_{B1} = 50 mAdc)		t_{on}	–	20	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 0.5 Adc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	–	50	60	ns

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 — TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



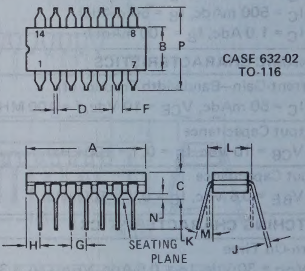
MHQ6001 (SILICON)
MHQ6002

QUAD DUAL-IN-LINE HERMETIC SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTORS

. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- DC Current Gain Specified – 1.0 to 300 mAdc
- High Current-Gain–Bandwidth Product – f_T = 400 MHz (Typ) @ I_C = 50 mAdc
- NPN Transistors Similar to 2N2218 or 2N2219
- PNP Transistors Similar to 2N2904 or 2N2905
- TO-116 Ceramic Package – Compact Size Compatible With IC Automatic Insertion Equipment
- End to End Pin Out Available

QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTORS



CASE 632-02
TO-116

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15⁰	–	15⁰
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

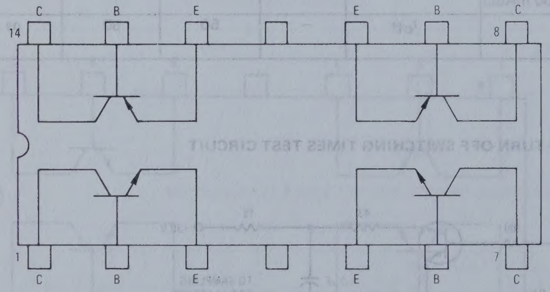
NOTE:

DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		Each Transistor	Total Device	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.65 3.72	1.9 10.88	Watts mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.3 7.43	4.6 26.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc	MHQ6001		25	–	–	
	MHQ6002		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MHQ6001		35	–	–	
	MHQ6002		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MHQ6001		40	–	–	
	MHQ6002		100	–	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MHQ6001		20	–	–	
	MHQ6002		30	–	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.4	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 kHz)		f_T	–	400	–	MHz
Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	NPN		–	6.0	–	
	PNP		–	4.5	–	
Input Capacitance		C_{ib}				pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	NPN		–	20	–	
	PNP		–	17	–	
SWITCHING CHARACTERISTICS (Figure 1)						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)		t_{on}	–	30	–	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	–	225	–	ns

(1)Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle = 2%.

NPN SATURATED SWITCHING TIME TEST CIRCUITS

For PNP Switching Tests, reverse the diodes, voltage polarities, and input pulses.

FIGURE 1 — NPN TURN-ON TIME

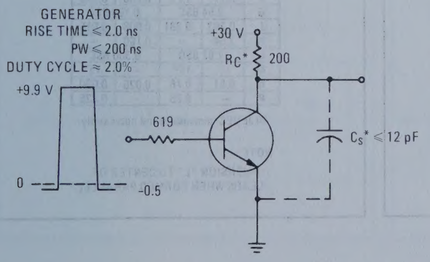
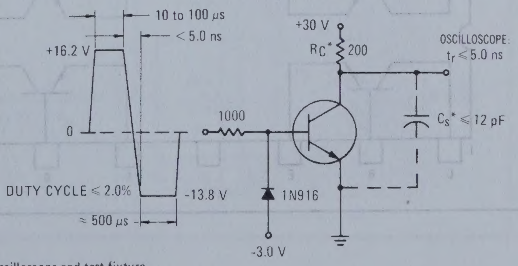

GENERATOR
RISE TIME ≤ 2.0 ns
PW ≤ 200 ns
DUTY CYCLE ≈ 2.0%
+9.9 V
0
-0.5
619
+30 V
RC* 200
Cs* ≤ 12 pF

FIGURE 2 — NPN TURN-OFF TIME


10 to 100 µs
< 5.0 ns
+16.2 V
0
DUTY CYCLE ≤ 2.0%
-13.8 V
≈ 500 µs
1000
1N916
-3.0 V
+30 V
RC* 200
OSCILLOSCOPE:
tr ≤ 5.0 ns
Cs* ≤ 12 pF

*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

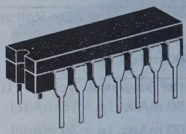
MHQ6100 (SILICON)
MHQ6100A

QUAD DUAL-IN-LINE HERMETIC SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTORS

. . . designed for complementary circuits where low-level, low-noise amplification is required.

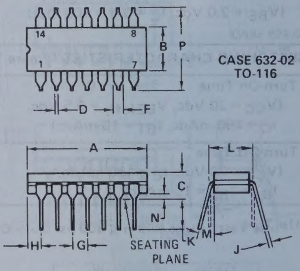
- Low Collector Cutoff Current –
  I_{CBO} = 10 nAdc (Max) @ V_{CB} = 50 Vdc
- PNP Transistor Similar to 2N3798
- NPN Transistor Similar to 2N930
- TO-116 Ceramic Packaging – Compact Size Compatible With IC Automatic Insertion Equipment
- End to End Pin Out Available

QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MHQ6100	MHQ6100A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Total Device	
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.5 2.86	1.5 8.58	Watts mW/°C
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 5.71	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C



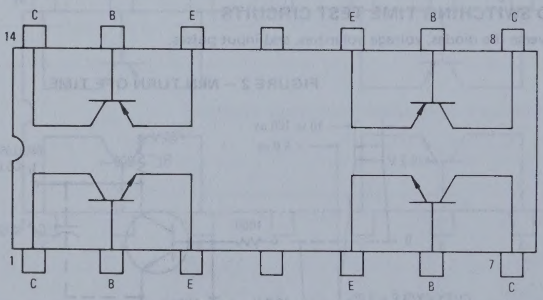
CASE 632-02
TO-116

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.8	19.9	0.660	0.785
B	5.59	7.11	0.220	0.280
C	–	5.08	–	0.200
D	0.381	0.584	0.015	0.023
F	0.77	1.77	0.030	0.070
G	2.54 BSC		0.100 BSC	
J	0.203	0.381	0.008	0.015
K	2.54	–	0.100	–
L	7.62 BSC		0.300 BSC	
M	–	15^o	–	15^o
N	0.51	0.76	0.020	0.030
P	–	8.25	–	0.325

All JEDEC dimensions and notes apply.

NOTE:
DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.

CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MHQ6100 MHQ6100A	BV_{CEO}	40 45	– –	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		50 100	– –	– –	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	– –	– –	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		75 150	– –	– –	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MHQ6100 MHQ6100A		60 125	– –	– –	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{BE(sat)}$	–	–	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	NPN PNP	f_T	– –	175 130	– –	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	NPN PNP	C_{ob}	– –	4.5 2.3	– –	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	NPN PNP	C_{ib}	– –	6.0 5.5	– –	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

MHW559

The RF Line

LOW NOISE WIDEBAND AMPLIFIER MODULE

. . . designed specifically for broadband applications requiring low noise characteristics. Specified for use in CATV distribution equipment.

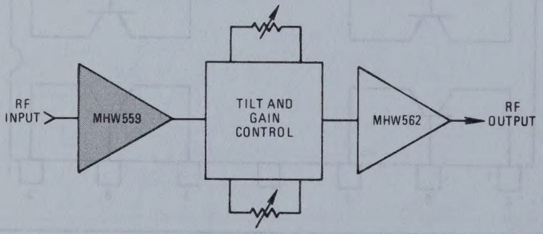
- Specified +50 dBmV Output, 24 Vdc Distortion Characteristics –
  Triple Beat = –74 dB (Max)
  21 Channel Cross Modulation = –54 dB (Max)
  Second Order = –64 dB (Max)
- Broadband Power Gain –
  G_p = 15.5 dB (Min)
- Broadband Noise Figure –
  NF = 8.5 dB (Max) @ f = 300 MHz
- Hermetic Package

ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	–	300	MHz
Power Gain	G_p	15.5	16.5	17.5	dB
Slope	S	–	–	+1.0	dB
Gain Flatness	–	–	–	±0.2	dB
Input Return Loss (Z_o = 75 Ohms)	Z_{in}	18	20	–	dB
Output Return Loss (Z_o = 75 Ohms)	Z_{out}	18	20	–	dB
21 Channel Crossmodulation Distortion(1) (P_{out} = +50 dBmV)	XMD	–	–	-54	dB
Second Order Intermodulation Distortion (P_{out} = +50 dBmV, Ch2 + Ch13 = ChR)	IMD	–	–	-64	dB
Triple Beat (P_{out} = +50 dBmV, Ch 3 + Ch 4 + Ch A = 250 MHz)	TB	–	-78	-74	dB
Noise Figure (f = 300 MHz)	NF	–	–	8.5	dB
DC Current (T_C = 30°C)	I_{DC}	–	190	230	mA

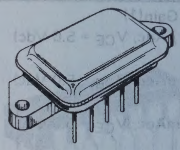
(1) Tested at Ch 2 and Ch 13.

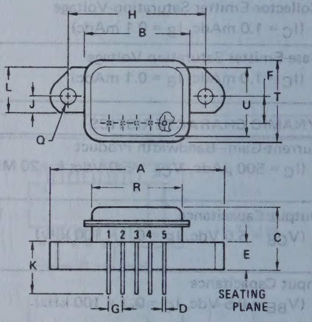
FIGURE 1 – TYPICAL APPLICATION IN TRUNK AMPLIFIER



WIDEBAND AMPLIFIER MODULE

40-300 MHz





STYLE 1:
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	46.99	48.01	1.850	1.890
B	29.46	30.48	1.160	1.200
C	14.35	15.11	0.565	0.595
D	0.69	0.84	0.027	0.033
E	4.95	5.46	0.195	0.215
F	7.62	8.26	0.300	0.325
G	4.06 BSC		0.160 BSC	
H	37.97	38.23	1.495	1.505
J	4.57	4.83	0.180	0.190
K	9.14	10.67	0.360	0.420
L	12.32	13.08	0.485	0.515
Q	3.99	4.24	0.157	0.167
R	24.94	25.20	0.982	0.992
T	23.11	24.13	0.910	0.950
U	18.47	18.72	0.727	0.737

CASE 270-02

MHW560

The RF Line

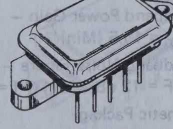
LOW NOISE WIDEBAND AMPLIFIER MODULE

. . . designed specifically for broadband applications requiring low noise characteristics. Specified for use in CATV distribution equipment.

- Specified +50 dBmV Output, 24 Vdc Distortion Characteristics —
  Triple Beat = −70 dB (Max)
  21 Channel Cross Modulation = −51 dB (Max)
  Second Order = −60 dB (Max)
- Broadband Power Gain —
  G_p = 15.5 dB (Min)
- Broadband Noise Figure —
  NF = 8.5 dB (Max) @ f = 300 MHz
- Hermetic Package

WIDEBAND AMPLIFIER MODULE

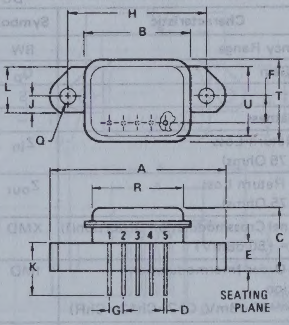
40-300 MHz



ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	300	MHz
Power Gain	G_p	15.5	—	17.5	dB
Slope	S	—	—	+1.0	dB
Gain Flatness	—	—	—	±0.2	dB
Input Return Loss (Z_o = 75 Ohms)	Z_{in}	16	—	—	dB
Output Return Loss (Z_o = 75 Ohms)	Z_{out}	16	—	—	dB
21 Channel Crossmodulation Distortion(1) (P_{out} = +50 dBmV)	XMD	—	—	−51	dB
Second Order Intermodulation Distortion (P_{out} = +50 dBmV, Ch2 + Ch13 = ChR)	IMD	—	—	−60	dB
Triple Beat (P_{out} = +50 dBmV, Ch 3 + Ch 4 + Ch A = 250 MHz)	TB	—	−72	−70	dB
Noise Figure (f = 300 MHz)	NF	—	—	8.5	dB
DC Current (T_C = 30°C)	I_{DC}	—	190	230	mA

(1) Tested at Ch 2 and Ch 13.



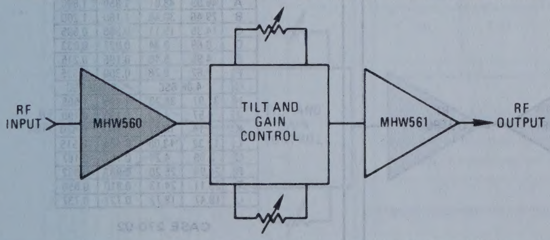
STYLE 1:
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	46.99	48.01	1.850	1.890
B	29.46	30.48	1.160	1.200
C	14.35	15.11	0.565	0.595
D	0.69	0.84	0.027	0.033
E	4.95	5.46	0.195	0.215
F	7.62	8.26	0.300	0.325
G	4.06 BSC		0.160 BSC	
H	37.97	38.23	1.495	1.505
J	4.57	4.83	0.180	0.190
K	9.14	10.67	0.360	0.420
L	12.32	13.08	0.485	0.515
Q	3.99	4.24	0.157	0.167
R	24.94	25.20	0.982	0.992
T	23.11	24.13	0.910	0.950
U	18.47	18.72	0.727	0.737

CASE 270-02

FIGURE 1 — TYPICAL APPLICATION IN LINE EXTENDER AMPLIFIER



The RF Line

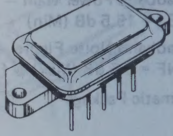
LOW DISTORTION WIDEBAND AMPLIFIER MODULE

. . . designed specifically for broadband applications requiring low distortion characteristics. Specified for use in CATV distribution equipment.

- Specified +50 dBmV Output, 24 Vdc Distortion Characteristics —
  Triple Beat = –74 dB (Max)
  21 Channel Cross Modulation = -54 dB (Max)
  Second Order = –66 dB (Max)
- Broadband Power Gain —
  G_p = 15.5 (Min)
- Broadband Noise Figure —
  NF = 12 dB (Max) @ f = 300 MHz
- Hermetic Package

WIDEBAND AMPLIFIER MODULE

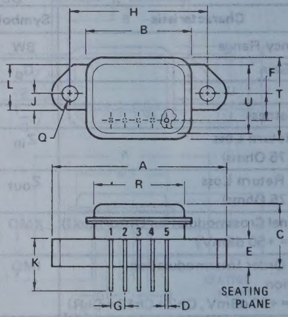
40-300 MHz



ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	300	MHz
Power Gain	G_p	15.5	—	17.5	dB
Slope	S	—	—	+1.0	dB
Gain Flatness	—	—	—	±0.2	dB
Input Return Loss (Z_o = 75 Ohms)	Z_{in}	16	—	—	dB
Output Return Loss (Z_o = 75 Ohms)	Z_{out}	16	—	—	dB
21 Channel Crossmodulation Distortion(1) (P_{out} = +50 dBmV)	XMD	—	—	-54	dB
Second Order Intermodulation Distortion (P_{out} = +50 dBmV, Ch2+Ch13 = ChR)	IMD	—	—	-66	dB
Triple Beat (P_{out} = +50 dBmV, Ch 3 + Ch 4 + Ch A = 250 MHz)	TB	—	-78	-74	dB
Noise Figure (f = 300 MHz)	NF	—	—	12	dB
DC Current (T_C = 30°C)	I_{DC}	—	200	230	mA

(1) Tested at Ch 2 and Ch 13.



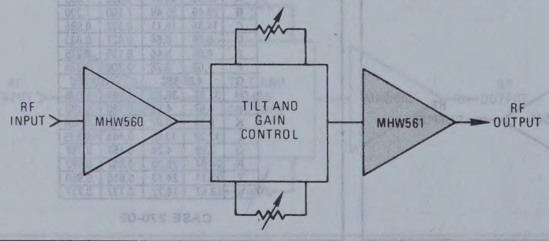
STYLE 1:
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	46.99	48.01	1.850	1.890
B	29.46	30.48	1.160	1.200
C	14.35	15.11	0.565	0.595
D	0.69	0.84	0.027	0.033
E	4.95	5.46	0.195	0.215
F	7.62	8.26	0.300	0.325
G	4.06 BSC		0.160 BSC	
H	37.97	38.23	1.495	1.505
J	4.57	4.83	0.180	0.190
K	9.14	10.67	0.360	0.420
L	12.32	13.08	0.485	0.515
Q	3.99	4.24	0.157	0.167
R	24.94	25.20	0.982	0.992
T	23.11	24.13	0.910	0.950
U	18.47	18.72	0.727	0.737

CASE 270-02

FIGURE 1 — TYPICAL APPLICATION IN LINE EXTENDER AMPLIFIER



The RF Line

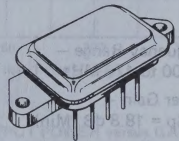
LOW DISTORTION WIDEBAND AMPLIFIER MODULE

. . . designed specifically for broadband applications requiring low distortion characteristics. Specified for use in CATV distribution equipment.

- Specified +50 dBmV Output, 24 Vdc Distortion Characteristics —
  Triple Beat = −78 dB (Max)
  21 Channel Cross Modulation = −57 dB (Max)
  Second Order = −69 dB (Max)
- Broadband Power Gain —
  G_p = 15.5 dB (Min)
- Broadband Noise Figure —
  NF = 10 dB (Max) @ f = 300 MHz
- Hermetic Package

WIDEBAND AMPLIFIER MODULE

40-300 MHz

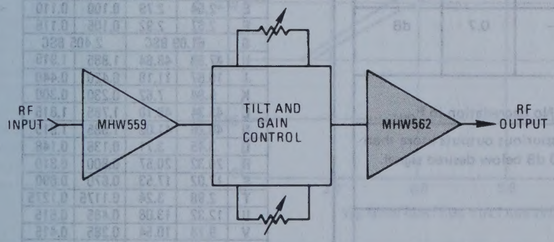


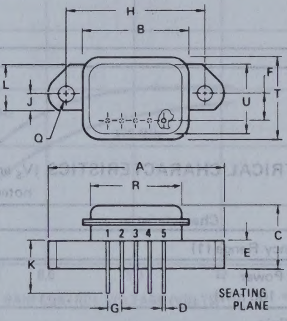
ELECTRICAL CHARACTERISTICS (V_{DC} = 24 Vdc)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency Range	BW	40	—	300	MHz
Power Gain	G_p	15.5	16.5	17.5	dB
Slope	S	—	—	+1.0	dB
Gain Flatness	—	—	±0.1	±0.2	dB
Input Return Loss (Z_o = 75 Ohms)	Z_{in}	18	20	—	dB
Output Return Loss (Z_o = 75 Ohms)	Z_{out}	18	20	—	dB
21 Channel Crossmodulation Distortion(1) (P_{out} = +50 dBmV)	XMD	—	—	−57	dB
Second Order Intermodulation Distortion (P_{out} = +50 dBmV, Ch2 + Ch13 = ChR)	IMD	—	—	−69	dB
Triple Beat (P_{out} = +50 dBmV, Ch 3 + Ch 4 + Ch A = 250 MHz)	TB	—	−80	−78	dB
Noise Figure (f = 300 MHz)	NF	—	—	10	dB
DC Current (T_C = 30°C)	I_{DC}	—	200	230	mA

(1) Tested at Ch 2 and Ch 13.

FIGURE 1 — TYPICAL APPLICATION IN TRUNK AMPLIFIER





STYLE 1:
PIN 1. RF IN
2. DC & RF GROUND
3. B+ INPUT
4. DC & RF GROUND
5. RF OUT

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	46.99	48.01	1.850	1.890
B	29.46	30.48	1.160	1.200
C	14.35	15.11	0.565	0.595
D	0.69	0.84	0.027	0.033
E	4.95	5.46	0.195	0.215
F	7.62	8.26	0.300	0.325
G	4.06 BSC		0.160 BSC	
H	37.97	38.23	1.495	1.505
J	4.57	4.83	0.180	0.190
K	9.14	10.67	0.360	0.420
L	12.32	13.08	0.485	0.515
Q	3.99	4.24	0.157	0.167
R	24.94	25.20	0.982	0.992
T	23.11	24.13	0.910	0.950
U	18.47	18.72	0.727	0.737

CASE 270-02

MHW709

The RF Line

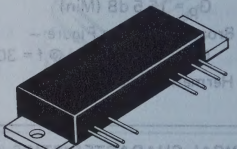
UHF POWER MODULE

. . . designed for Land Mobile Communications equipment in the UHF band.

- Frequency Range — 400 to 470 MHz
- Power Gain — G_p = 18.8 dB (Min)
- Output Power — P_{out} = 7.5 W (Min)

UHF POWER MODULE

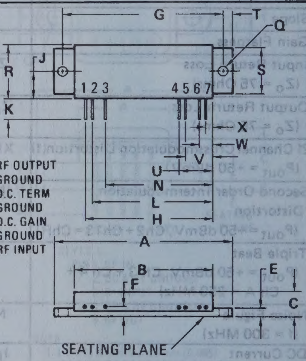
7.5 W, 12.5 V
400-470 MHz



ELECTRICAL CHARACTERISTICS (V_s and V_{sc} set at 12.5 Vdc unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Frequency Range (1)	—	400	470	MHz
Output Power (P_{in} = 100 mW)	P_{out}	7.5	—	Watts
Power Gain	Gp	18.8	—	dB
Efficiency (P_{out} = 7.5 W)	η	35	—	%
Harmonics (P_{out} = 7.5 W, Reference)	—	—	-40	dB
Input Impedance (P_{out} = 7.5 W, 50 Ohm Reference)	Z_{in}	—	2:1	VSWR
Power Degradation (P_{out} = 7.5 W, T_C = 25°C) (T_C = 0°C to 60°C)	—	—	0.3	dB
Power Degradation (P_{out} = 7.5 W, T_C = 25°C) (T_C = 0°C to 80°C)	—	—	0.7	dB
Load Mismatch (VSWR = ∞, V_s = 15 Vdc, P_{out} = 7.5 W)	—	No degradation in P_{out}		
Stability (P_{in} = 30 to 150 mW, Load Mismatch 2:1 50 Ohm Reference, V_s = 8.0 to 16 Vdc, V_{sc} adjusted for P_{out} = 5.0 to 12 W)	—	All spurious outputs more than 70 dB below desired signal.		

(1) Frequency Range is covered in two bands:
MHW709-1 400-440 MHz
MHW709-2 440-470 MHz



STYLE 1:
PIN 1. RF OUTPUT
2. GROUND
3. D.C. TERM
4. GROUND
5. D.C. GAIN
6. GROUND
7. RF INPUT

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	67.06	67.56	2.640	2.660
B	52.32	52.83	2.060	2.080
C	8.51	8.89	0.335	0.350
E	2.54	2.79	0.100	0.110
F	2.67	2.92	0.105	0.115
G	61.09 BSC		2.405 BSC	
H	47.88	48.64	1.885	1.915
J	10.67	11.18	0.420	0.440
K	5.84	7.62	0.230	0.300
L	45.34	46.10	1.785	1.815
N	40.26	41.02	1.585	1.615
Q	3.45	3.71	0.136	0.146
R	20.32	20.57	0.800	0.810
S	17.02	17.53	0.670	0.690
T	2.98	3.24	0.1175	0.1275
U	12.32	13.08	0.485	0.515
V	9.78	10.54	0.385	0.415
W	4.70	5.46	0.185	0.215
X	2.16	2.92	0.085	0.115

CASE 700-02

TYPICAL PERFORMANCE CURVES
(MHW709-2)

FIGURE 1 — INPUT POWER, EFFICIENCY, and VSWR versus FREQUENCY

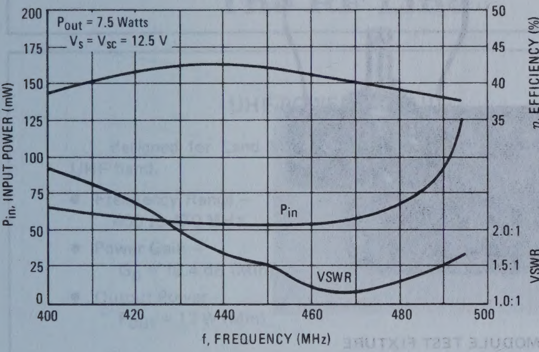


FIGURE 2 — OUTPUT POWER VERSUS INPUT POWER

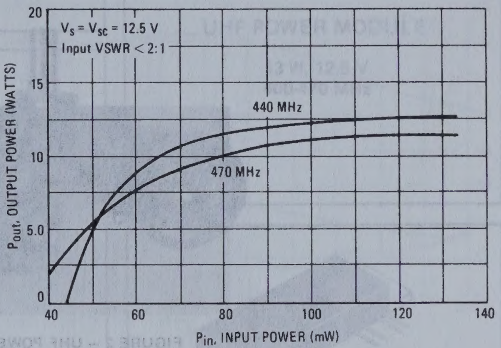


FIGURE 3 — OUTPUT POWER versus VOLTAGE

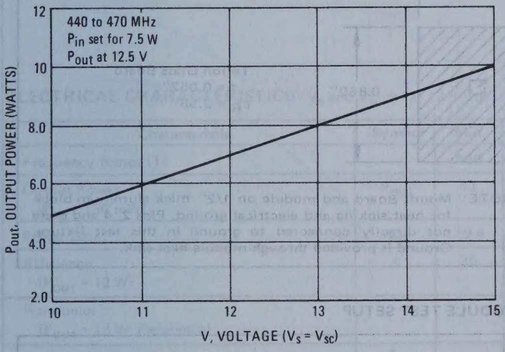


FIGURE 4 — OUTPUT POWER versus GAIN CONTROL VOLTAGE

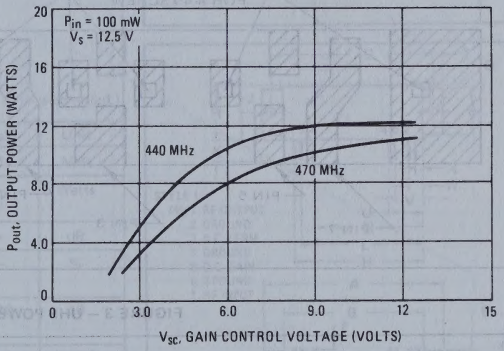
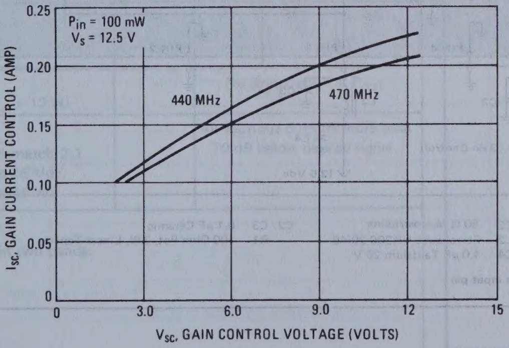


FIGURE 5 — GAIN CONTROL CURRENT versus VOLTAGE



UHF Power Module Test Information

FIGURE 1 – TEST CIRCUIT

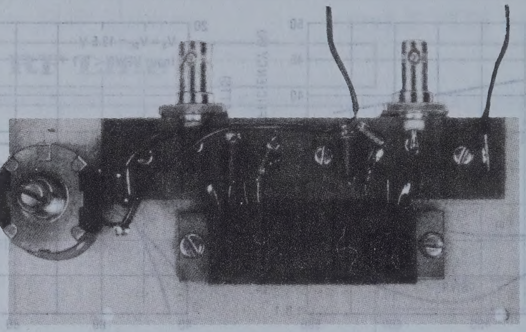
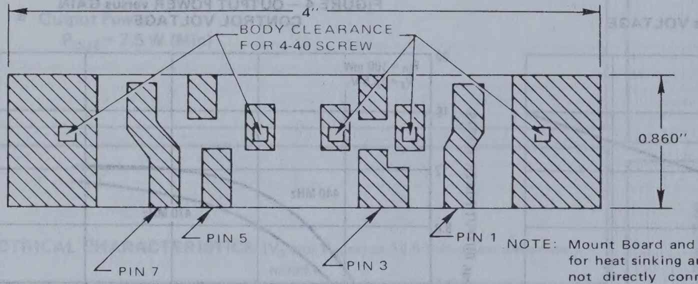
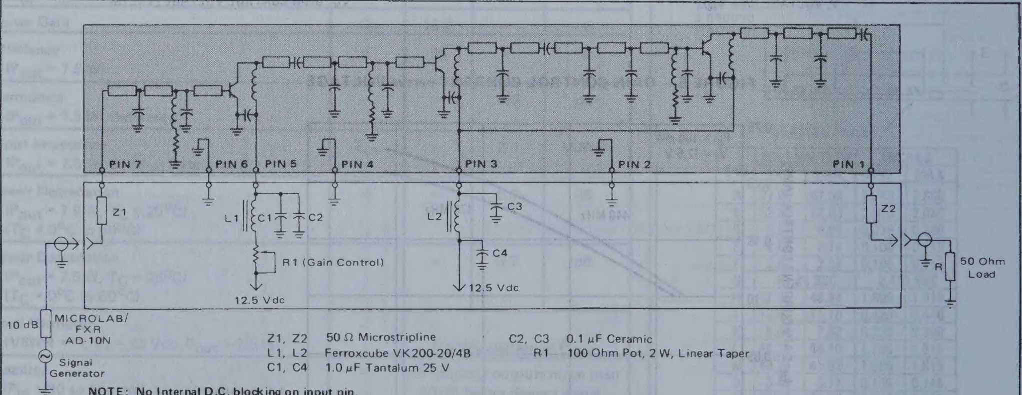


FIGURE 2 – UHF POWER MODULE TEST FIXTURE PRINTED CIRCUIT BOARD


4″
BODY CLEARANCE FOR 4-40 SCREW
0.860″
PIN 5
PIN 7
PIN 3
PIN 1
Teflon Glass Board
t = 0.062″
ε_R = 2.56

NOTE: Mount Board and module on 1/2″ thick aluminum block for heat sinking and electrical ground. Pins 2, 4 and 6 are not directly connected to ground in this test fixture. Ground is provided through module heat sink.

FIGURE 3 – UHF POWER MODULE TEST SETUP


PIN 7
PIN 6
PIN 5
PIN 4
PIN 3
PIN 2
PIN 1
Z1
Z2
L1
C1
C2
L2
C3
C4
R1 (Gain Control)
12.5 Vdc
12.5 Vdc
R
50 Ohm Load
10 dB
MICROLAB/ FXR AD-10N
Signal Generator

Z1, Z2 50 Ω Microstripline
L1, L2 Ferroxcube VK200-20/4B
C1, C4 1.0 μF Tantalum 25 V
C2, C3 0.1 μF Ceramic
R1 100 Ohm Pot, 2 W, Linear Taper

NOTE: No Internal D.C. blocking on input pin.

MHW710

The RF Line

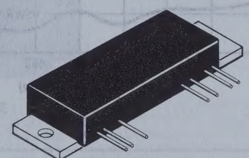
UHF POWER MODULE

. . . designed for Land Mobile Communications equipment in the UHF band.

- Frequency Range –
  400 to 470 MHz
- Power Gain –
  G_p = 19.4 dB (Min)
- Output Power –
  P_{out} = 13 W (Min)

UHF POWER MODULE

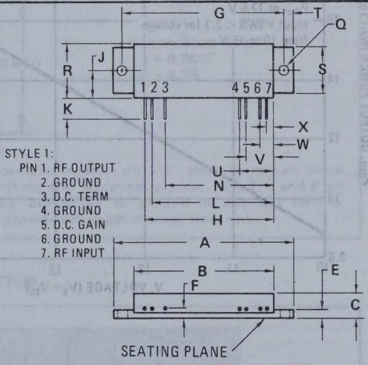
13 W, 12.5 V
400-470 MHz



ELECTRICAL CHARACTERISTICS (V_s and V_{sc} set at 12.5 Vdc unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Frequency Range (1)	–	400	470	MHz
Output Power (P_{in} = 150 mW)	P_{out}	13	–	Watts
Power Gain	G_p	19.4	–	dB
Efficiency (P_{out} = 13 W)	η	35	–	%
Harmonics (P_{out} = 13 W, Reference)	–	–	-40	dB
Input Impedance (P_{out} = 13 W, 50 Ohm Reference)	Z_{in}	–	2:1	VSWR
Power Degradation (P_{out} = 13 W, T_C = 25°C) (T_C = 0°C to 60°C)	–	–	0.3	dB
Power Degradation (P_{out} = 13 W, T_C = 25°C) (T_C = 0°C to 80°C)	–	–	0.7	dB
Load Mismatch (VSWR = ∞, V_s = 15 Vdc, P_{out} = 13 W)	–	No degradation in P_{out}		
Stability (P_{in} = 50 to 200 mW, Load Mismatch 2:1 50 ohm reference, V_s = 8.0 to 16 Vdc, V_{sc} adjusted for P_{out} = 5.0 to 16 W)	–	All spurious outputs more than 70 dB below desired signal.		

(1) Frequency Range is covered in two bands:
MHW710-1 400-440 MHz
MHW710-2 440-470 MHz



STYLE 1:
PIN 1. RF OUTPUT
2. GROUND
3. D.C. TERM
4. GROUND
5. D.C. GAIN
6. GROUND
7. RF INPUT

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	67.06	67.56	2.640	2.660
B	52.32	52.83	2.060	2.080
C	8.51	8.89	0.335	0.350
E	2.54	2.79	0.100	0.110
F	2.67	2.92	0.105	0.115
G	61.09 BSC		2.405 BSC	
H	47.88	48.64	1.885	1.915
J	10.67	11.18	0.420	0.440
K	5.84	7.62	0.230	0.300
L	45.34	46.10	1.785	1.815
N	40.26	41.02	1.585	1.615
Q	3.45	3.71	0.136	0.146
R	20.32	20.57	0.800	0.810
S	17.02	17.53	0.670	0.690
T	2.98	3.24	0.1175	0.1275
U	12.32	13.08	0.485	0.515
V	9.78	10.54	0.385	0.415
W	4.70	5.46	0.185	0.215
X	2.16	2.92	0.085	0.115

CASE 700-02

TYPICAL PERFORMANCE CURVES

(MHW710-2)

FIGURE 1 – INPUT POWER, EFFICIENCY AND VSWR versus FREQUENCY

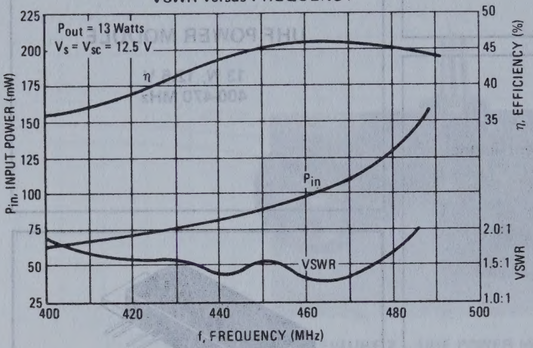


FIGURE 2 – OUTPUT POWER versus INPUT POWER

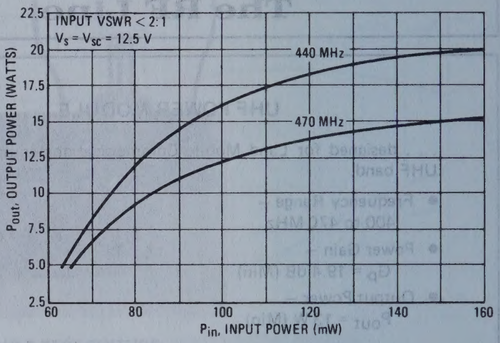


FIGURE 3 – OUTPUT POWER versus VOLTAGE

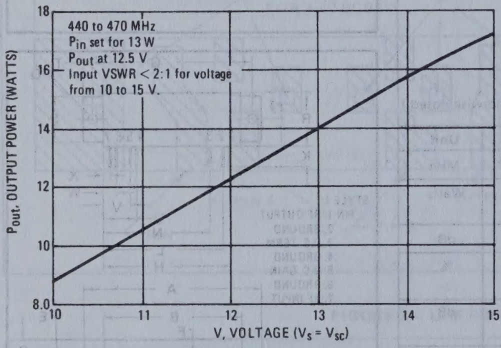


FIGURE 4 – OUTPUT POWER versus GAIN CONTROL VOLTAGE

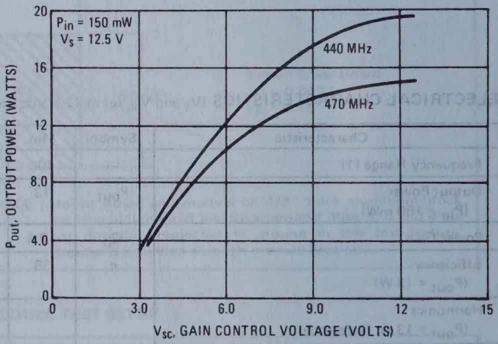
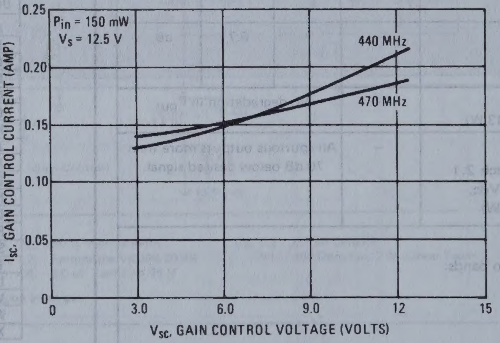


FIGURE 5 – GAIN CONTROL CURRENT versus VOLTAGE



UHF Power Module Test Information

FIGURE 1 – TEST CIRCUIT

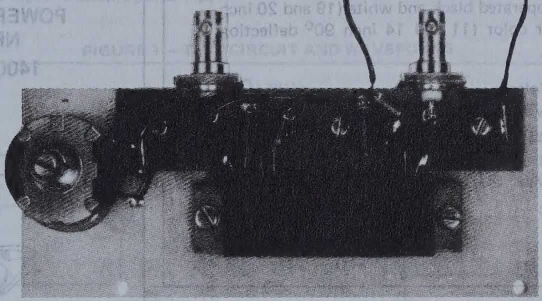
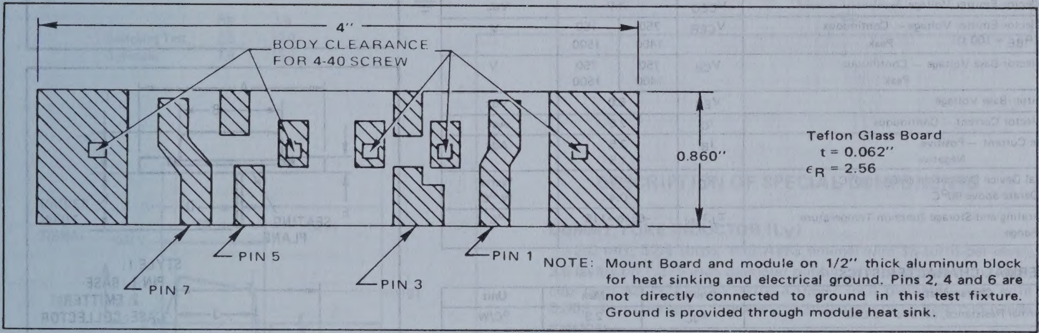
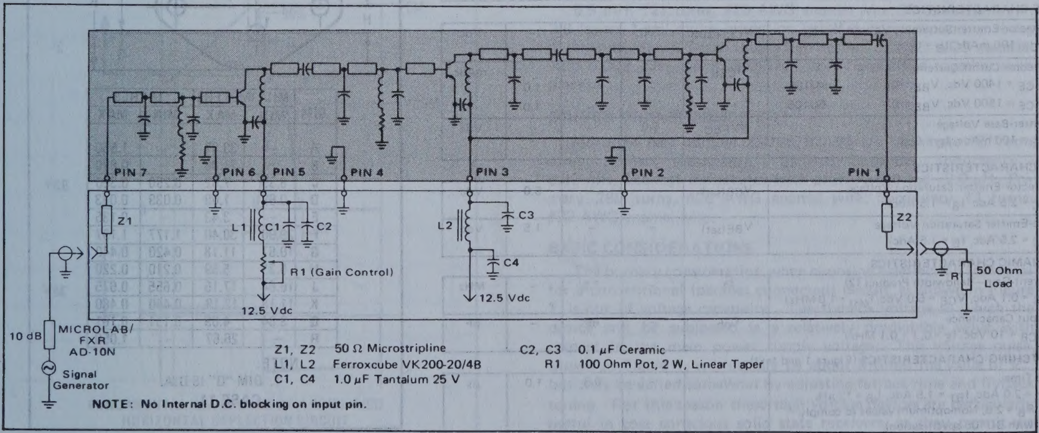


FIGURE 2 – UHF POWER MODULE TEST FIXTURE PRINTED CIRCUIT BOARD


4″
BODY CLEARANCE FOR 4-40 SCREW
0.860″
Teflon Glass Board
t = 0.062″
ϵ_R = 2.56
PIN 7
PIN 5
PIN 3
PIN 1

NOTE: Mount Board and module on 1/2″ thick aluminum block for heat sinking and electrical ground. Pins 2, 4 and 6 are not directly connected to ground in this test fixture. Ground is provided through module heat sink.

FIGURE 3 – UHF POWER MODULE TEST SETUP


PIN 7
PIN 6
PIN 5
PIN 4
PIN 3
PIN 2
PIN 1
Z1
L1
C1
C2
R1 (Gain Control)
12.5 Vdc
L2
C3
C4
12.5 Vdc
Z2
R
50 Ohm Load
10 dB
MICROLAB/ FXR AD-10N
Signal Generator

Z1, Z2	50 Ω Microstripline	C2, C3	0.1 µF Ceramic
L1, L2	Ferroxcube VK200-20/4B	R1	100 Ohm Pot, 2 W, Linear Taper
C1, C4	1.0 µF Tantalum 25 V		

NOTE: No Internal D.C. blocking on input pin.

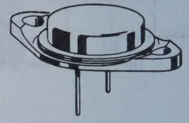
MJ105 (SILICON)
BU105

HORIZONTAL DEFLECTION SILICON TRANSISTORS

. . . designed for use in line operated black and white (19 and 20 inch 110° deflection circuits) or color (11 and 14 inch 90° deflection circuits) television receivers.

- High Collector-Emitter Voltage —
  V_{CER} (Peak) = 1400 Vdc — MJ105
  = 1500 Vdc — BU105
- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 5.0 Vdc (Max) @ I_C = 2.5 Adc
- Fall Time @ I_C = 2.0 Adc —
  t_f = 0.5 μs (Typ)
  = 1.0 μs (Max)

2.5 AMPERE
POWER TRANSISTORS
NPN SILICON
1400, 1500 VOLTS
10 WATTS



MAXIMUM RATINGS

Rating	Symbol	MJ105	BU105	Unit
Collector-Emitter Voltage	V_{CEO}	750		Vdc
Collector-Emitter Voltage — Continuous (R_{BE} = 100 Ω) Peak	V_{CER}	750 1400	750 1500	V
Collector-Base Voltage — Continuous Peak	V_{CB}	750 1400	750 1500	V
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.5		Adc
Base Current — Positive Negative	I_B	2.5 1.5		Adc
Total Device Dissipation @ T_C = 90°C Derate above 90°C	P_D	10 0.4		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +115		°C

THERMAL CHARACTERISTICS

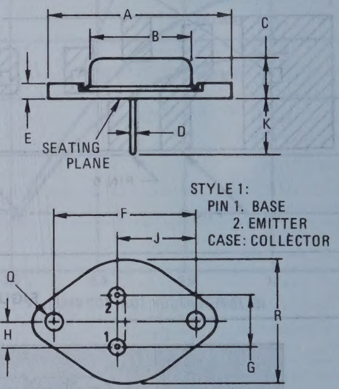
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$BV_{CEO(sus)}$	750	—	—	Vdc
Collector Cutoff Current (V_{CE} = 1400 Vdc, V_{BE} = 0) MJ105 (V_{CE} = 1500 Vdc, V_{BE} = 0) BU105	I_{CES}	 — —	 — —	 1.0 1.0	mAdc
Emitter-Base Voltage (I_E = 100 mAdc, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 1.5 Adc)	$V_{CE(sat)}$	—	—	5.0	Vdc
Base-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 1.5 Adc)	$V_{BE(sat)}$	—	—	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (2) (I_C = 0.1 Adc, V_{CE} = 5.0 Vdc, f_{test} = 1.0 MHz)	f_T	—	7.5	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	—	65	—	pF
SWITCHING CHARACTERISTICS (Figure 1 and text)					
Fall Time (I_C = 2.0 Adc, I_{B1} = 1.5 Adc, L_B = 12 μH, R_B = 2.5, Non-optimum values to comply with BU105 specification)	t_f	—	0.5	1.0	μs

(1) Pulse Test: Pulse Width 300 μs, Duty Cycle ≈ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

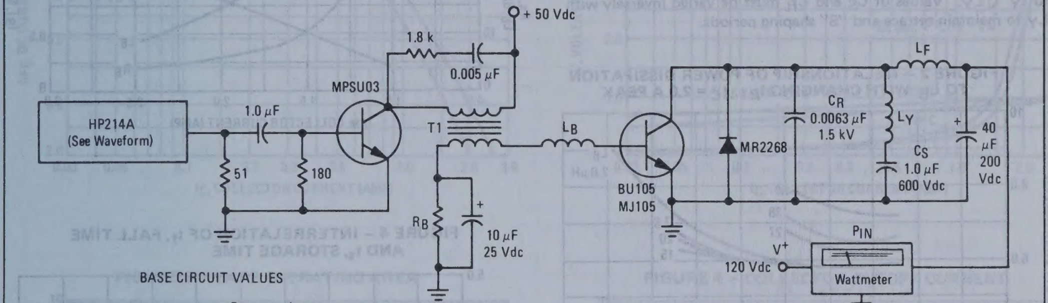
NOTE:
1. DIM "Q" IS DIA.

CASE 11

CIRCUIT OPTIMIZATION

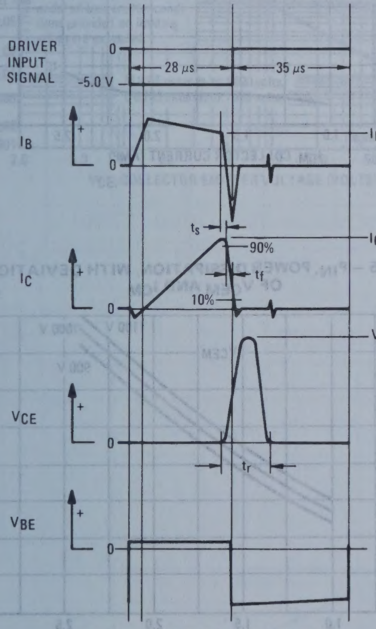
Test/application circuit and operating waveforms for BU105/MJ105 are shown in Figure 1. It may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, the circuit was designed with operating efficiency in mind, so that it could be used to evaluate devices by one simple criterion, supply power input. Excessive power input can be caused by a variety of problems, but it is the dissipation itself that is of fundamental importance. Once the transistor operating point has been established, fixed circuit values may be selected for the test fixture. Factory testing may then be made with one meter reading, without adjustment of the test apparatus.

FIGURE 1 — TEST CIRCUIT AND WAVEFORMS



BASE CIRCUIT VALUES

	R_B	L_B
Switching Test	2.5	12.0
Optimum	7.0	15.0



FUNDAMENTAL WAVEFORMS OF A SIMPLIFIED HORIZONTAL DEFLECTION CIRCUIT

DESCRIPTION OF SPECIAL COMPONENTS

DUMMY YOKE INDUCTOR (L_Y)

2.0 mH, 52.5 turns, #16 AWG enamel wire 15 turns per layer, 3.5 layers on 1.375 inch diameter bobbin, enclosed in a Ferroxcube, cup core K535221-B2A, with a 0.687 inch diameter core, with 0.003 inch core gap. Use a nylon bolt and nut to hold cup halves together.

DUMMY HIGH VOLTAGE AND HORIZONTAL SCAN TRANSFORMER (L_F)

5.5 mH, 121 turns, #20 AWG enamel wire 33 turns per layer, 3.6 layers 1 mil mylar insulation between layers wound on 1 leg of Allen Bradley 0.5 inch square Ferrite "U" core (2) WO3 material with 0.007 inch gap in each leg. Core halves held together with plastic.

DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A05-1/4" laminate "E" iron core. Primary Inductance - 39 mH, Secondary Inductance - 0.22 mH, Leakage inductance with primary shorted - 2.0 μH. Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

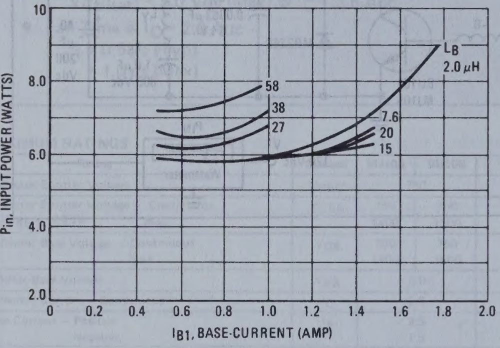
BASIC CONSIDERATIONS

The primary consideration when choosing a deflection transistor for a conventional (parallel connected) circuit, as shown in Figure 1, is one of voltage capability. The flyback voltage to which the device will be subjected is a relatively predictable value with respect to the main power supply voltage. This voltage pulse, shown in Figure 1, will usually be about 8 times the value of V^+, but may be varied somewhat by adjusting retrace time and flyback tuning. For this reason these high voltage devices are particularly useful in cost conscious solid state receivers, as they permit the use of an off-the-line half wave power supply.

COLLECTOR CIRCUIT VALUES

The power supply used in the circuit of Figure 1, was chosen to produce a 1000 volt collector pulse on the transistor, a conservative value, recommended for unregulated applications. The values of yoke (L_Y), flyback primary (L_F), retrace capacitor (C_R), and "S" shaping capacitor (C_S) shown, will result in a peak collector current of about 2.0 A. This is sufficient to deflect (and provide high voltage for) large screen 110° black and white or small 90° color receivers. Peak collector currents to 2.5 A may be handled by the BU105/MJ105. Holding the supply constant for most efficient application, adjustment of amount of deflection may be made by raising or lowering L_Y and L_F. Remember that $L_Y I_Y$ is constant for the fixed voltage situation, and actual deflection is proportional to $I_Y \sqrt{L_Y}$. Values of C_S and C_R must be varied inversely with L_Y to maintain retrace and "S" shaping periods.

FIGURE 2 – RELATIONSHIP OF POWER DISSIPATION TO L_B, WITH CHANGING I_{B1}, I_C = 2.0 A PEAK



BASE CIRCUIT VALUES

The driver power supply and driver transistor type can be selected according to convenience. A TO-5 or Uniwatt type will generally be needed. Once this is done, the turns ratio of the driver transformer can be picked to produce about 4 to 5 volts peak to peak at the base of the output device. Tight coupling between windings is recommended on early designs to allow optimizing leakage inductance by adding inductance externally. Later, the leakage can be "designed in" to the transformer. The R_B and its bypass electrolytic, often called the "speed up" circuit, allows adjustment of I_{B1} (or I_B "end of scan" or I_B end) while still providing a low ac impedance for good turn-off of the output device. In Figure 2, the effects of varying L_B and I_{B1} on the total power input to the deflection circuit are shown. Note that an optimum L_B can be found which will produce low dissipation over a wide range of I_{B1}. This is desirable in order to produce efficient operation over a wide range of circuit component tolerances. Likewise, best L_B also gives the least sensitivity to output transistor h_{FE}.

The best value of L_B found in Figure 2 is 15 µH. Remember that this is the sum of the actual leakage inductance of the transformer (secondary inductance with primary shorted) and an external L, if necessary. The best value of I_{B1} is 0.8 A achieved in the typical device by using R_B = 7 Ω, derived experimentally.

These are the choices recommended for the test fixture, when the transistor is used at I_{CM} = 2.0 A. For other values of I_{CM} the drive circuit components must be changed. Figure 3 shows the values of L_B and I_{B1} which should be used.

The value of R_B which will be required to produce the I_{B1} is also given, but of course, it is not an independent variable.

PERFORMANCE

Shown in Figures 4 and 5 are the results which will be typically obtained with the test circuit at various operating conditions.

FIGURE 3 – INTERRELATION OF R_B, L_B, AND I_{B1}

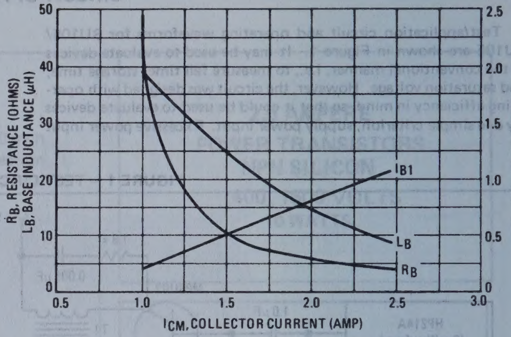


FIGURE 4 – INTERRELATION OF t_f, FALL TIME AND t_s, STORAGE TIME

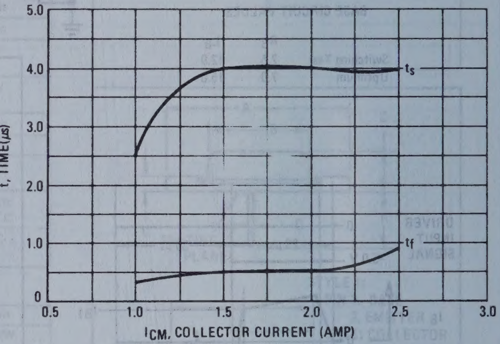
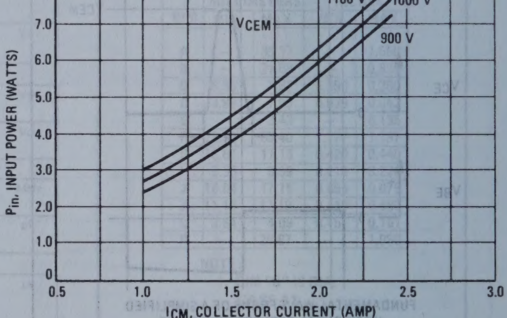


FIGURE 5 – P_{IN}, POWER DISSIPATION, WITH DEVIATIONS OF V_{CEM} AND I_{CM}



TYPICAL TRANSISTOR CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

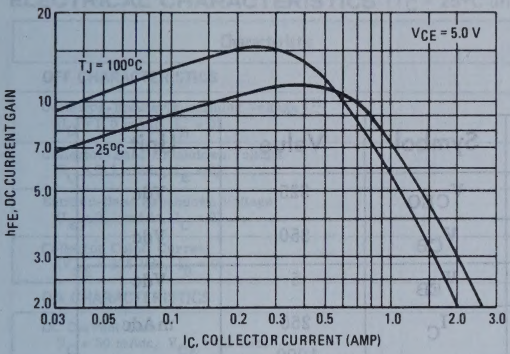


FIGURE 2 – "ON" VOLTAGES

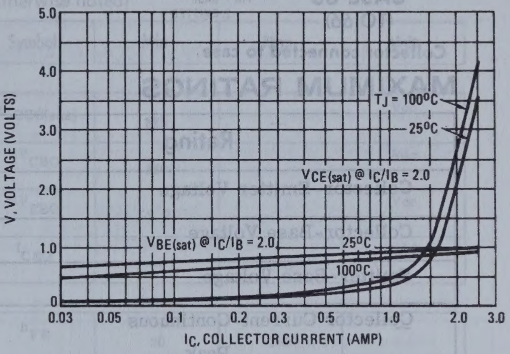


FIGURE 3 – SAFE OPERATING AREA

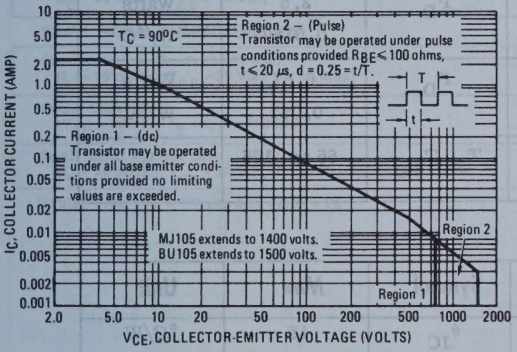
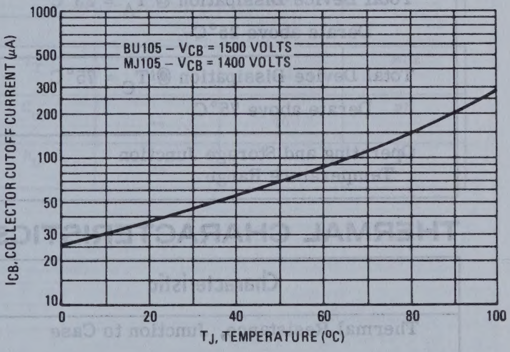
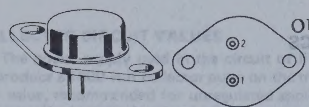


FIGURE 4 – COLLECTOR CUTOFF CURRENT



MJ400 (SILICON)

High-voltage NPN silicon transistor designed for video output circuitry in color television receivers.



CASE 80
(TO-66)

PIN 1. BASE
2. EMITTER

Collector connected to case

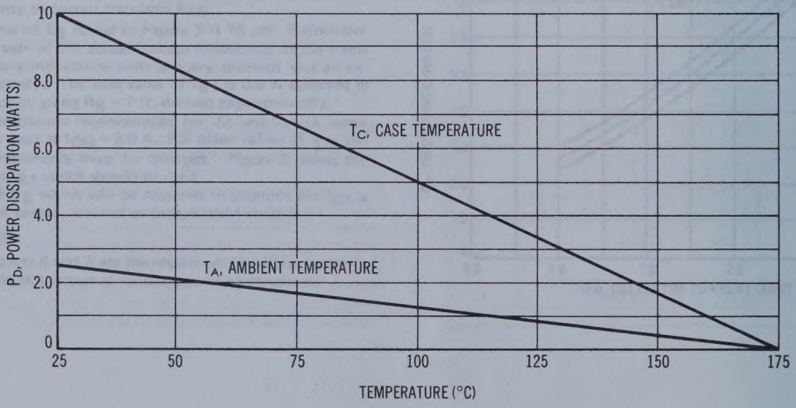
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	325	Vdc
Collector-Base Voltage	V_{CB}	350	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current-Continuous Peak	I_C	250 1000	mAdc
Base Current	I_B	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	2.5 0.0167	Watts W/°C
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	6.67 0.067	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	15	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	60	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$	325	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 325 Vdc, I_B = 0)	I_{CEO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	300	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 10 MHz)	f_T	15	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	10	pF
Small Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{fe}	25	—	—

(1) Pulse Test: PW ≦ 300 μs, duty cycle ≦ 2%

FIGURE 2 — CURRENT GAIN CHARACTERISTICS

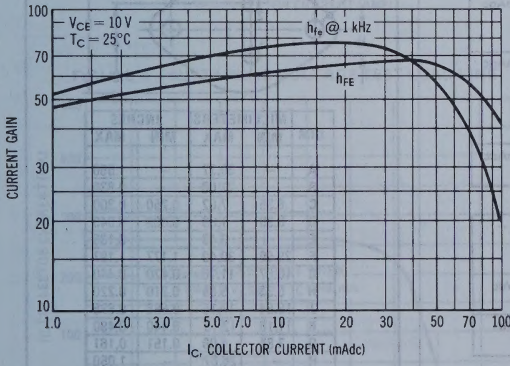
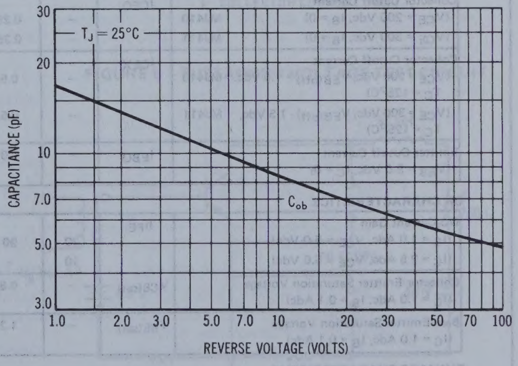


FIGURE 3 — OUTPUT CAPACITANCE



MJ410 (SILICON)
MJ411

HIGH VOLTAGE NPN SILICON TRANSISTORS

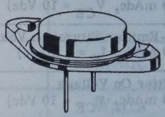
. . . designed for medium to high voltage inverters, converters, regulators and switching circuits.

- High Collector-Emitter Voltage –
  V_{CEO} = 200 Volts – MJ410
  300 Volts – MJ411
- DC Current Gain Specified @ 1.0 and 2.5 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.8 Vdc @ I_C = 1.0 Adc

5 AMPERE

POWER TRANSISTORS
NPN SILICON

200–300 VOLTS
100 WATTS



MAXIMUM RATINGS

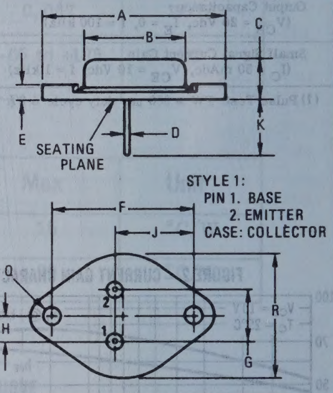
Rating	Symbol	MJ410	MJ411	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	Vdc
Collector-Base Voltage	V_{CB}	200	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous Peak	I_C	5.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ $T_C = 75^oC$ Derate above 75°C	P_D	100 1.33		Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.75	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	MJ410		200	–	
	MJ411		300	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 200 Vdc, I_B = 0)	MJ410		–	0.25	
(V_{CE} = 300 Vdc, I_B = 0)	MJ411		–	0.25	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 200 Vdc, $V_{EB(off)}$ = 1.5 Vdc, $T_C = 125^oC$)	MJ410		–	0.5	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ - 1.5 Vdc, $T_C = 125^oC$)	MJ411		–	0.5	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			30	90	
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.5	–	MHz



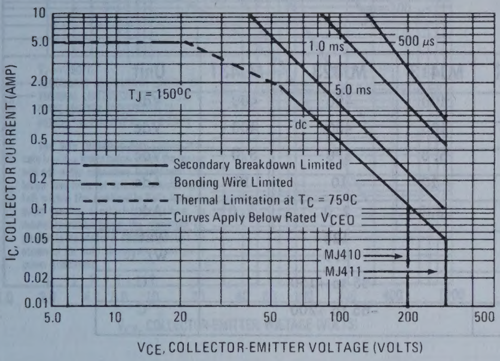
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. DIM "Q" IS DIA.

CASE 11

FIGURE 1 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 2 – DC CURRENT GAIN

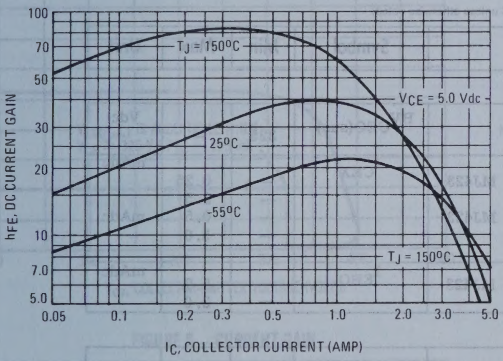


FIGURE 3 – "ON" VOLTAGES

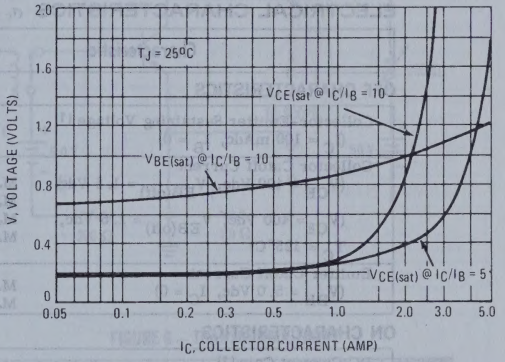


FIGURE 4 – SUSTAINING VOLTAGE TEST LOAD LINE

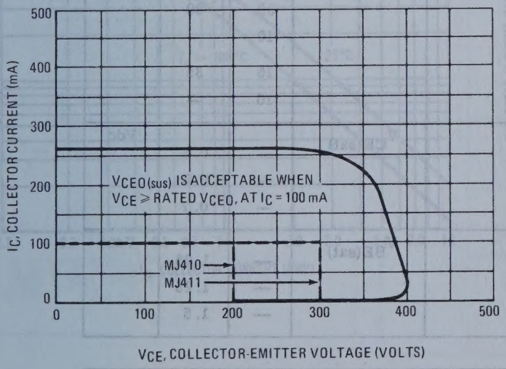
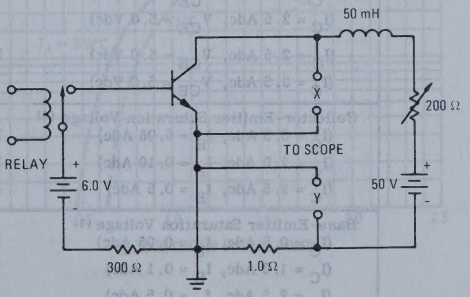
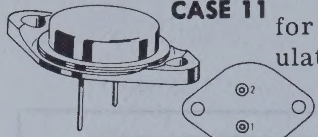


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJ413 (SILICON)
MJ423
MJ431



CASE 11

High-voltage NPN silicon transistors designed for medium-to-high-voltage inverters, converters, regulators and switching circuits.

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	MJ413	MJ423	MJ431	Unit
Collector-Emitter Voltage	V_{CEX}	400	400	400	Vdc
Collector-Base Voltage	V_{CB}	400	400	400	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	10	10	10	Adc
Base Current	I_B	2.0	2.0	2.0	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	125 1.0			Watts W/°C
Operation Junction Temperature Range	T_J	-65 to +150			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)		$BV_{CEO(sus)}$	325	—	Vdc
Collector Cutoff Current (V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ413, MJ423	I_{CEX}	—	0.25	mAdc
	MJ431		—	2.5	
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	MJ413, MJ423		—	0.5	mAdc
	MJ431		—	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	MJ413, MJ423	I_{EBO}	—	5.0	mAdc
	MJ431		—	2.0	
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	MJ413	h_{FE}	20	80	—
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			15	—	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	MJ423		30	90	
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)			10	—	
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)	MJ431		15	35	
(I_C = 3.5 Adc, V_{CE} = 5.0 Vdc)			10	—	
Collector-Emitter Saturation Voltage (1) (I_C = 0.5 Adc, I_B = 0.05 Adc)	MJ413	$V_{CE(sat)}$	—	0.8	Vdc
(I_C = 1.0 Adc, I_B = 0.10 Adc)	MJ423		—	0.8	
(I_C = 2.5 Adc, I_B = 0.5 Adc)	MJ431		—	0.7	
Base-Emitter Saturation Voltage (1) (I_C = 0.5 Adc, I_B = 0.05 Adc)	MJ413	$V_{BE(sat)}$	—	1.25	Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ423		—	1.25	
(I_C = 2.5 Adc, I_B = 0.5 Adc)	MJ431		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10Vdc, f = 1.0 MHz)		f_T	2.5	—	MHz

(1) PW $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%

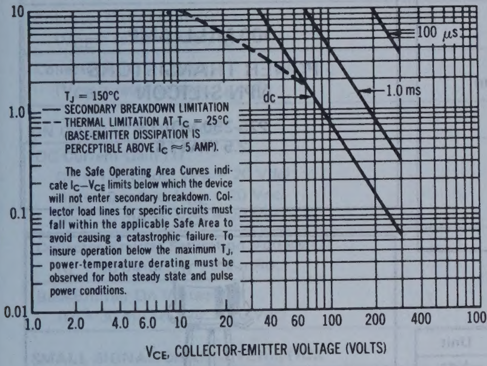


FIGURE 1 — ACTIVE-REGION SAFE-OPERATING AREA
10
1.0
0.1
0.01
I_C, COLLECTOR CURRENT (AMP)
100 μs
1.0 ms
dc
T_J = 150°C
— SECONDARY BREAKDOWN LIMITATION
- - THERMAL LIMITATION AT T_C = 25°C (BASE-EMITTER DISSIPATION IS PERCEPTIBLE ABOVE I_C ≈ 5 AMP).
The Safe Operating Area Curves indicate I_C—V_CE limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.
1.0
2.0
4.0
6.0
10
20
40
60
100
200
400
1000
V_CE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

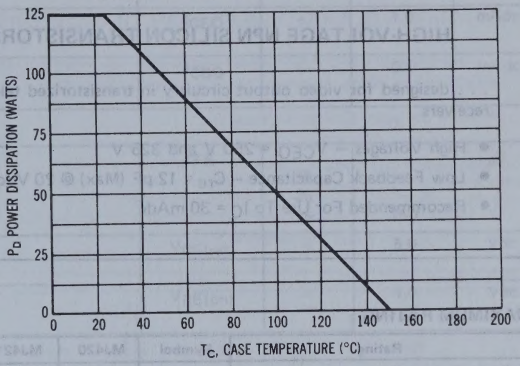


FIGURE 2 — POWER-TEMPERATURE DERATING CURVE
125
100
75
50
25
0
P_D POWER DISSIPATION (WATTS)
0
20
40
60
80
100
120
140
160
180
200
T_C, CASE TEMPERATURE (°C)

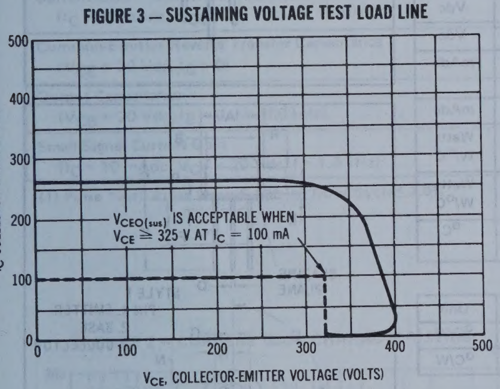


FIGURE 3 — SUSTAINING VOLTAGE TEST LOAD LINE
500
400
300
200
100
0
I_C COLLECTOR CURRENT (mA)
V_CEO(sus) IS ACCEPTABLE WHEN V_CE ≥ 325 V AT I_C = 100 mA
0
100
200
300
400
500
V_CE, COLLECTOR-EMITTER VOLTAGE (VOLTS)

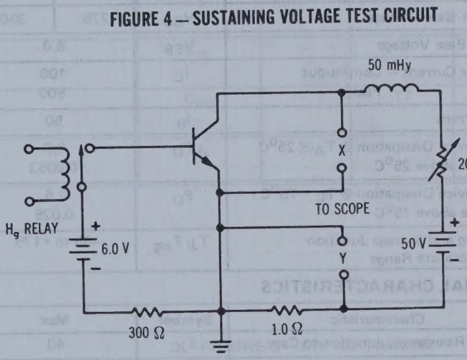


FIGURE 4 — SUSTAINING VOLTAGE TEST CIRCUIT
50 mHy
X
200 Ω
TO SCOPE
H_g RELAY
6.0 V
Y
50 V
300 Ω
1.0 Ω

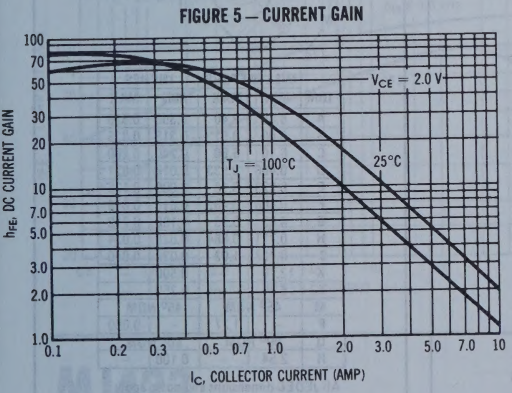


FIGURE 5 — CURRENT GAIN
100
70
50
30
20
10
7.0
5.0
3.0
2.0
1.0
h_FE, DC CURRENT GAIN
V_CE = 2.0 V
T_J = 100°C
25°C
0.1
0.2
0.3
0.5
0.7
1.0
2.0
3.0
5.0
7.0
10
I_C, COLLECTOR CURRENT (AMP)

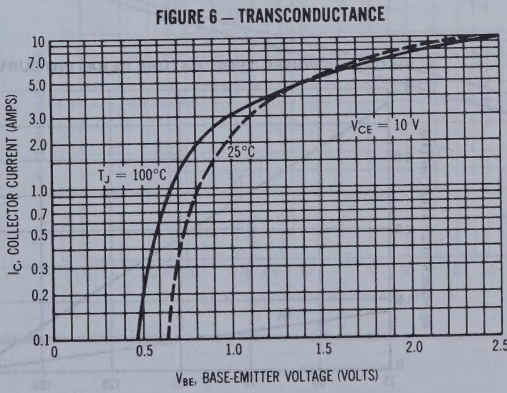


FIGURE 6 — TRANSCONDUCTANCE
10
7.0
5.0
3.0
2.0
1.0
0.7
0.5
0.3
0.2
0.1
I_C, COLLECTOR CURRENT (AMPS)
V_CE = 10 V
25°C
T_J = 100°C
0
0.5
1.0
1.5
2.0
2.5
V_BE, BASE-EMITTER VOLTAGE (VOLTS)

MJ420S (SILICON)
MJ421S

HIGH-VOLTAGE NPN SILICON TRANSISTORS

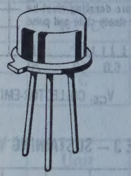
. . . designed for video output circuitry in transistorized television receivers

- High Voltages – V_{CEO} = 250 V and 325 V
- Low Feedback Capacitance – C_{re} = 12 pF (Max) @ 20 Vdc
- Recommended For Use To I_C = 30 mAdc

100 MILLIAMP

POWER TRANSISTORS
NPN SILICON

275-350 VOLTS
2.5 WATTS

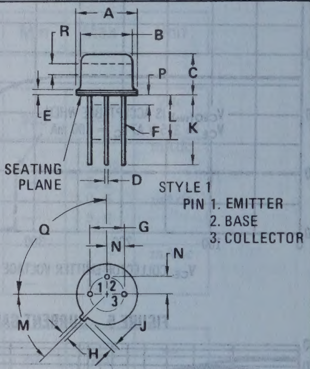


MAXIMUM RATING

Rating	Symbol	MJ420	MJ421	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Base Voltage	V_{CB}	275	350	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous Peak	I_C	100 500		mAdc
Base Current	I_B	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 0.0053		Watts W/°C
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	2.5 0.025		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	40	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	187	°C/W

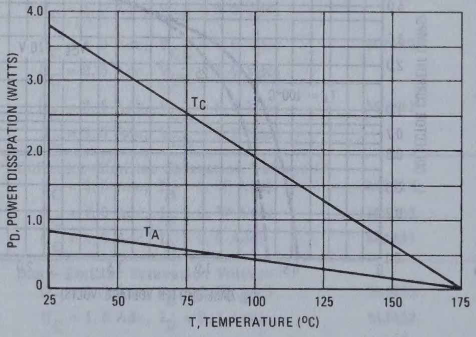


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	MJ420 MJ421	$V_{CEO(sus)}$	250 325	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	MJ420 MJ421	BV_{CBO}	275 350	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CE} = rated voltage, I_B = 0)		I_{CEO}	–	1.0	mAdc
Collector Cutoff Current (V_{CB} = rated voltage, I_E = 0)		I_{CBO}	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 20 Vdc) (I_C = 10 mAdc, V_{CE} = 20 Vdc) (I_C = 30 mAdc, V_{CE} = 20 Vdc)		h_{FE}	 15 25 25	 – – 250	–
Collector-Emitter Saturation Voltage (1) (I_C = 30 mAdc, I_B = 3.0 mAdc)		$V_{CE(sat)}$	–	5.0	Vdc
Base-Emitter On Voltage (1) (I_C = 30 mAdc, V_{CE} = 20 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 10 MHz)		f_T	15	–	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CE} = 20 Vdc, I_C = 0)		C_{re}	–	12	pF
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	12	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

(1) Pulse Test: Pulse Width≤300 μs, Duty Cycle≤2.0%

FIGURE 2 – CURRENT GAIN CHARACTERISTICS

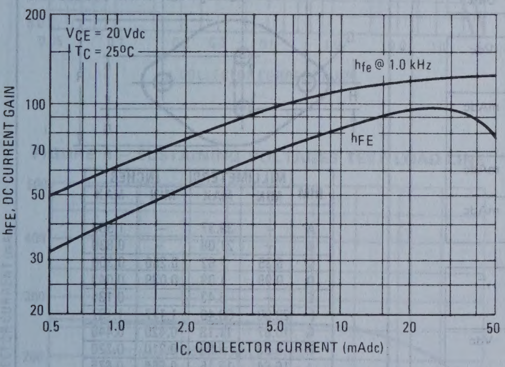
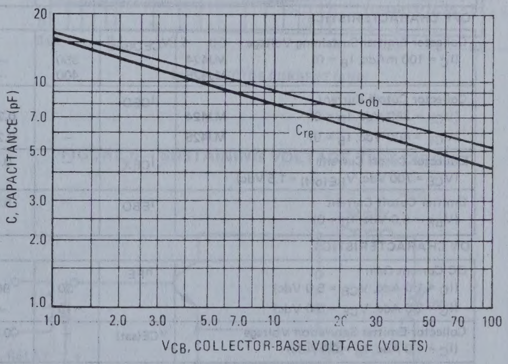


FIGURE 3 – CAPACITANCES



MJ423

For Specifications, See MJ413 Data.

MJ424 (SILICON)
MJ425

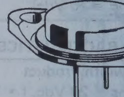
HIGH VOLTAGE NPN SILICON TRANSISTORS

. . . designed for use in high voltage applications in deflection circuits, switching regulators, inverters, and line operated amplifiers.

- High Collector-Emitter Voltage – V_{CEX} = 700 Vdc
- Excellent DC Current Gain – h_{FE} = 10 (Min) @ I_C = 2.5 Adc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.8 Vdc (Max) @ I_C = 1.0 Adc

5 AMPERE
POWER TRANSISTORS
NPN SILICON

350–400 VOLTS
100 WATTS



MAXIMUM RATINGS

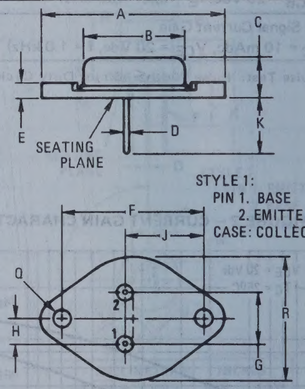
Rating	Symbol	MJ424	MJ425	Unit
Collector-Emitter Voltage	V_{CEO}	350	400	Vdc
Collector-Emitter Voltage	V_{CEX}	700		Vdc
Collector-Base Voltage	V_{CB}	700		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous Peak	I_C	5.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	100 1.33		Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.75	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0) MJ424 MJ425	$V_{CEO(sus)}$	 350 400	 – –	Vdc
Collector Cutoff Current (V_{CE} = 350 Vdc, I_B = 0) MJ424 (V_{CE} = 400 Vdc, I_B = 0) MJ425	I_{CEO}	 – –	 0.25 0.25	mAdc
Collector Cutoff Current (V_{CE} = 700 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{CEX}	–	0.5	mAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	 30 10	 90 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.5	–	MHz



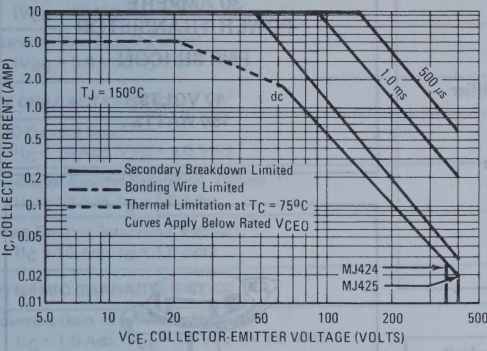
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. DIM "Q" IS DIA.

CASE 11

FIGURE 1 – SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 2 – DC CURRENT GAIN

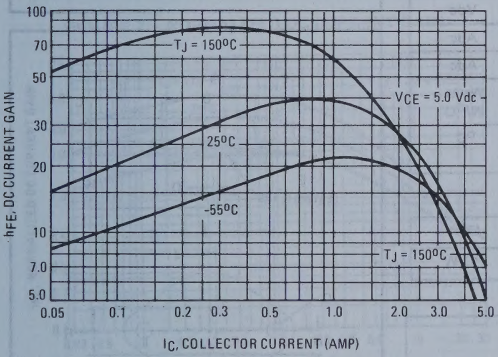


FIGURE 3 – "ON" VOLTAGES

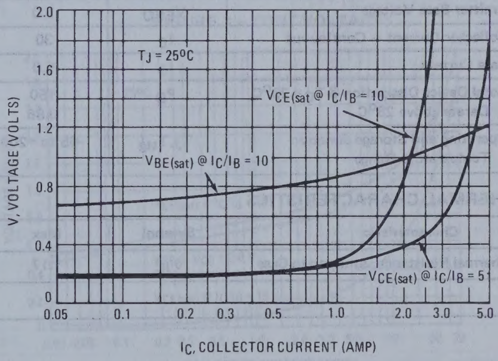


FIGURE 4 – SUSTAINING VOLTAGES TEST LOAD LINE

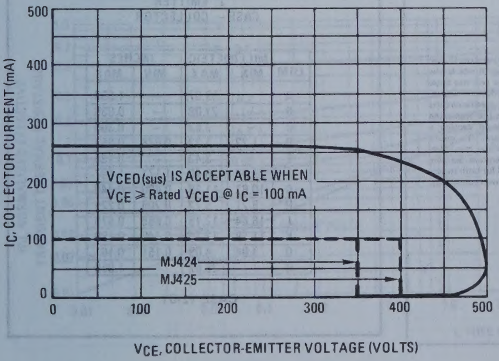
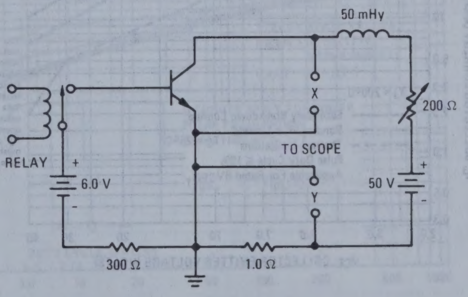


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJ431

For Specifications, See MJ413 Data.

MJ450 (SILICON)

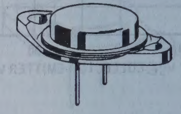
HIGH-POWER PNP SILICON TRANSISTOR

. . . designed for high-current switching and general purpose amplifier applications.

- Low Saturation Voltage – $V_{CE(sat)}$ = 1.0 Vdc @ I_C = 10 Adc
- DC Current Gain – h_{FE} = 20 (Min) @ I_C = 10 Adc
- Excellent Safe Area Characteristics

30 AMPERE
POWER TRANSISTOR
PNP SILICON

40 VOLTS
150 WATTS



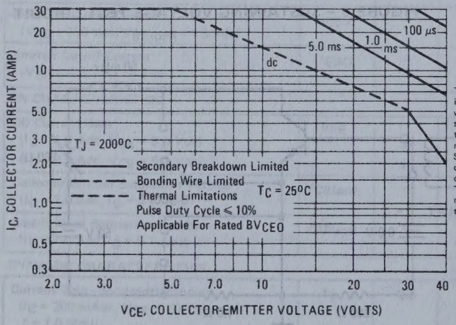
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	30	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	150 0.86	Watts $W/^{\circ}C$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^{\circ}C$

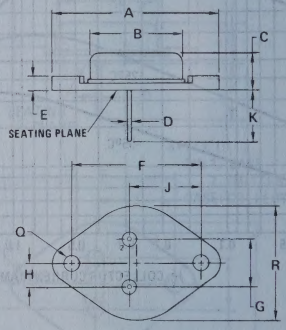
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	$^{\circ}C/W$

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE – COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 12-01

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	20	–	
Collector-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	–	1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – NORMALIZED DC CURRENT GAIN

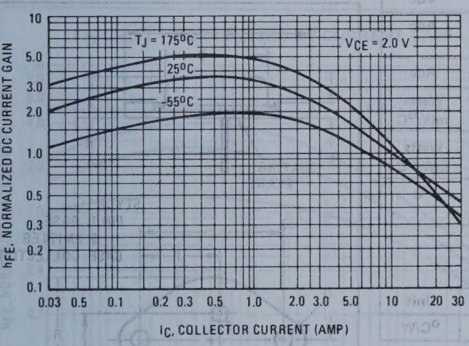


FIGURE 3 – "ON" VOLTAGES

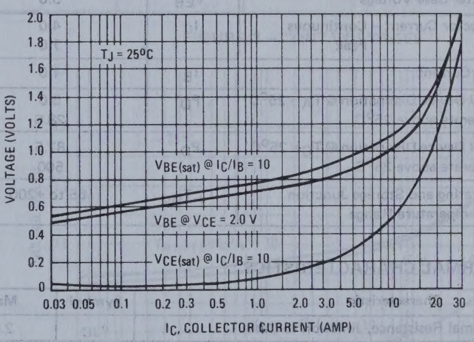
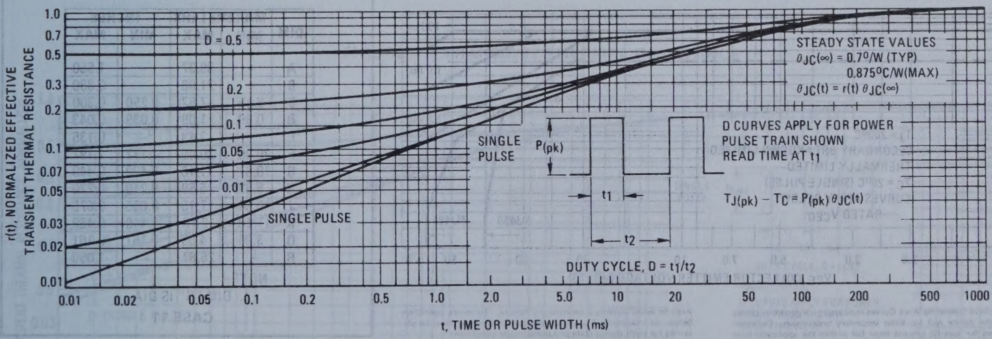


FIGURE 4 – THERMAL RESPONSE



MJ480 (SILICON)
MJ481

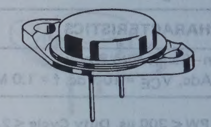
NPN SILICON POWER TRANSISTORS

. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain—Bandwidth Product — f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain — h_{FE} = 30-200 @ I_C = 1.0 Adc
- Complements to PNP MJ490 and MJ491

4 AMPERE
POWER TRANSISTORS
NPN SILICON

40-60 VOLTS
87.5 WATTS

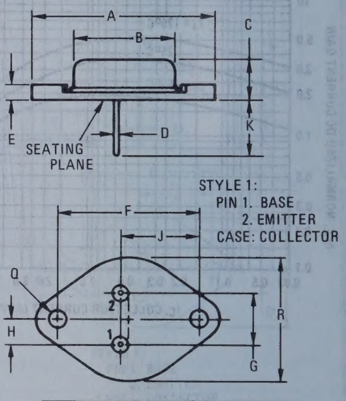


MAXIMUM RATINGS

Rating	Symbol	MJ480	MJ481	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W



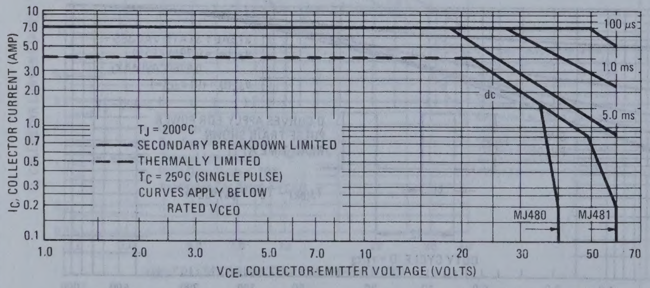
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. DIM "Q" IS DIA.

CASE 11

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	 MJ480 MJ481	BV_{CEO}	 40 60	 — —	Vdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0) (V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		I_{CBO}	 — —	 1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	 50 30 10	 — 200 —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{CE(sat)}$	 — —	 0.4 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	 — —	 1.0 1.5	Vdc
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	 — —	 1.2 1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	—	200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

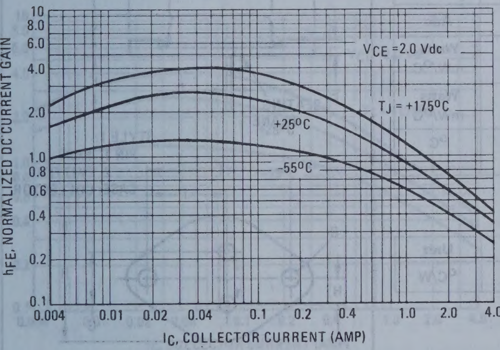


FIGURE 3 – "ON" VOLTAGES

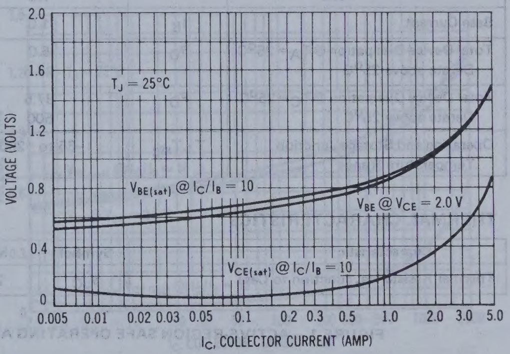
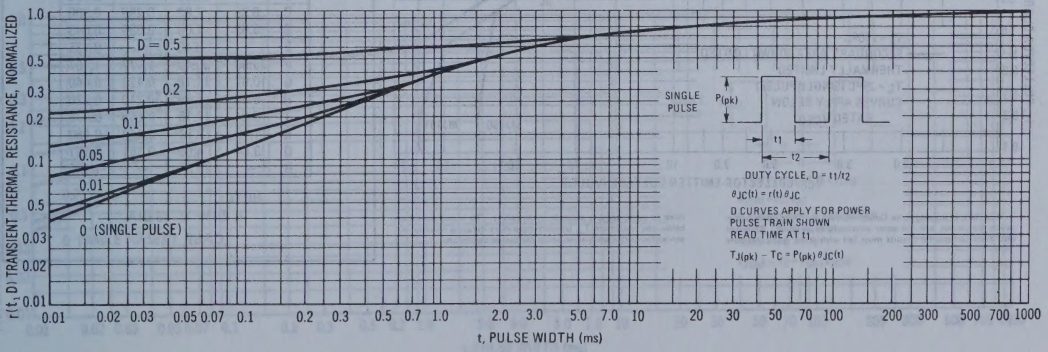


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



MJ490 (SILICON)
MJ491

PNP SILICON POWER TRANSISTORS

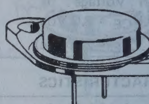
. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain—Bandwidth Product — f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain — h_{FE} = 30-200 @ I_C = 1.0 Adc
- Complements to NPN MJ480 and MJ481

4 AMPERE
POWER TRANSISTORS

PNP SILICON

40-60 VOLTS
87.5 WATTS

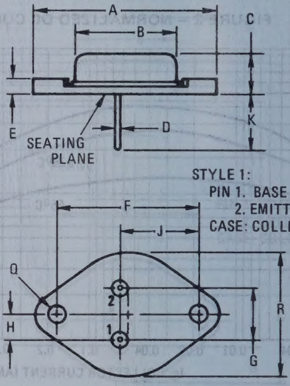


MAXIMUM RATINGS

Rating	Symbol	MJ490	MJ491	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W



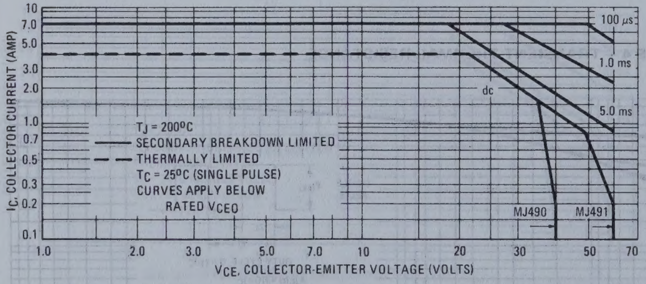
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. DIM "Q" IS DIA.

CASE 11

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	MJ490 MJ491	BV_{CEO}	40 60	– –	Vdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0) (V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		I_{CBO}	– –	1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	50 30 10	– 200 –	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{CE(sat)}$	– –	0.4 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	– –	1.0 1.5	Vdc
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	– –	1.2 1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

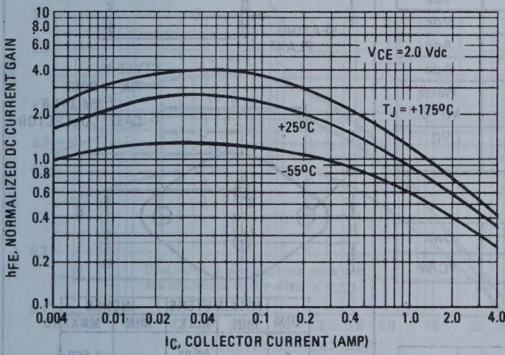


FIGURE 3 – "ON" VOLTAGE

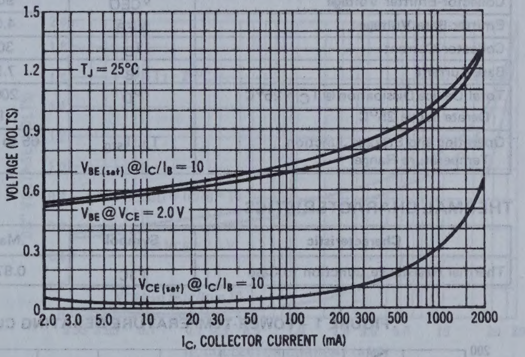
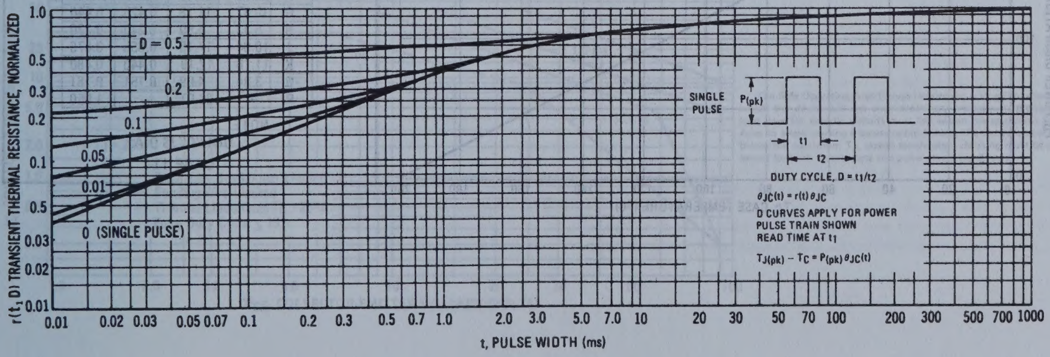


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



MJ802 (SILICON)

HIGH-POWER NPN SILICON TRANSISTOR

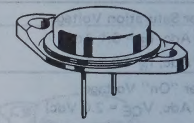
. . . for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

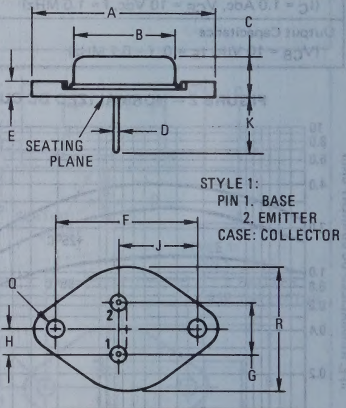
- High DC Current Gain – h_{FE} = 25-100 @ I_C = 7.5 A
- Excellent Safe Operating Area
- Complement to the PNP MJ4502

30 AMPERE
POWER TRANSISTOR

NPN SILICON

100 VOLTS
200 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. DIM "Q" IS DIA.

CASE 11

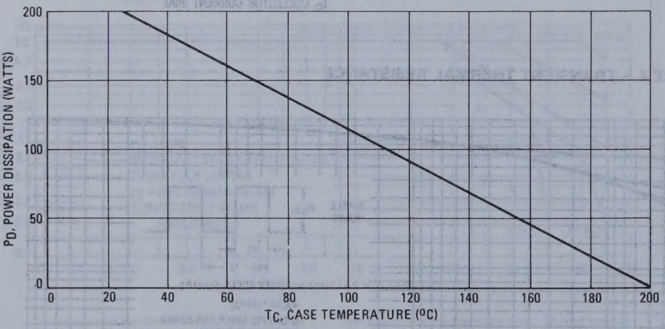
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CEO}	90	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	30	Adc
Base Current	I_B	7.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [(1)] (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}	100	–	Vdc
Collector-Emitter Sustaining Voltage [(1)] (I_C = 200 mAdc)	$V_{CEO(sus)}$	90	–	Vdc
Collector-Base Cutoff Current	I_{CBO}			mAdc
(V_{CB} = 100 Vdc, I_E = 0)		–	1.0	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)		–	5.0	
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain [(1)] (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter "On" Voltage [(1)] (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.3	Vdc
Collector-Emitter Saturation Voltage [(1)] (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage [(1)] (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{BE(sat)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

[(1)] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

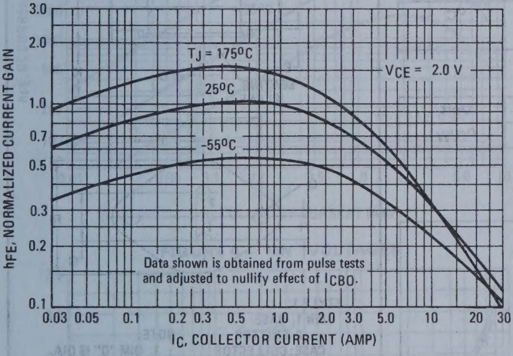


FIGURE 3 – "ON" VOLTAGES

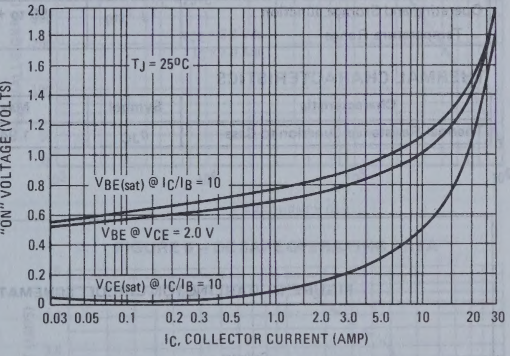
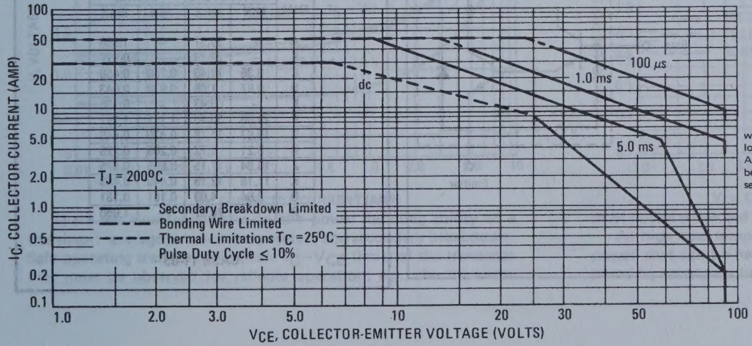


FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ900, MJ901 PNP (SILICON)
MJ1000, MJ1001 NPN

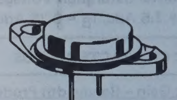
MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain – h_{FE} = 6000 (Typ) @ I_C = 3.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

8.0 AMPERE
DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON

60–80 VOLTS
90 WATTS

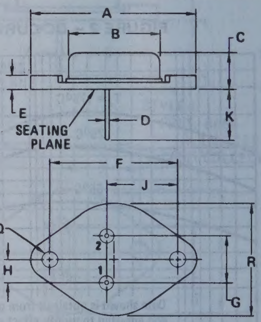


MAXIMUM RATINGS

Rating	Symbol	MJ900 MJ1000	MJ901 MJ1001	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	8.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	90 0.515		Watts W/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.94	$^oC/W$



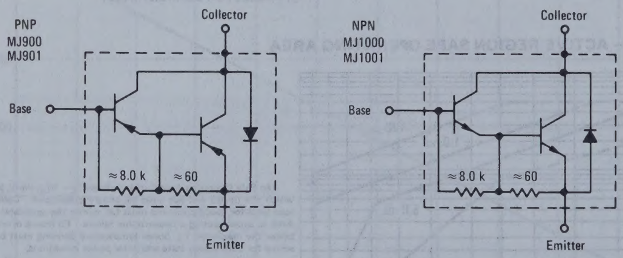
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 100 mAdc, I_B = 0)	MJ900, MJ1000 MJ901, MJ1001	BV_{CEO}	60 80	– –	Vdc
Collector Emitter Leakage Current (V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm) (V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm) (V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C) (V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C)	MJ900, MJ1000 MJ901, MJ1001 MJ900, MJ1000 MJ901, MJ1001	I_{CER}	– – – –	1.0 1.0 5.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
Collector-Emitter Leakage Current (V_{CE} = 30 Vdc, I_B = 0) (V_{CE} = 40 Vdc, I_B = 0)	MJ900, MJ1000 MJ901, MJ1001	I_{CEO}	– –	500 500	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	1000 750	– –	–
Collector-Emitter Saturation Voltage(1) (I_C = 3.0 Adc, I_B = 12 mAdc) (I_C = 8.0 Adc, I_B = 40 mAdc)		$V_{CE(sat)}$	– –	2.0 4.0	Vdc
Base-Emitter Voltage(1) (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	2.5	Vdc

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

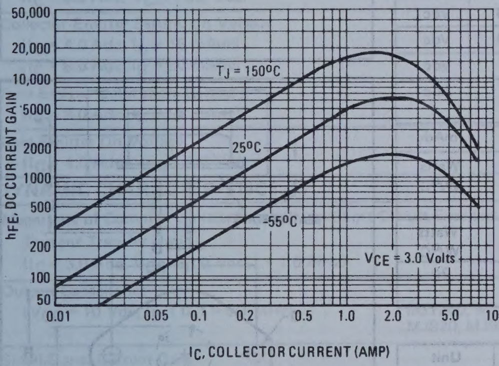


FIGURE 3 – SMALL-SIGNAL CURRENT GAIN

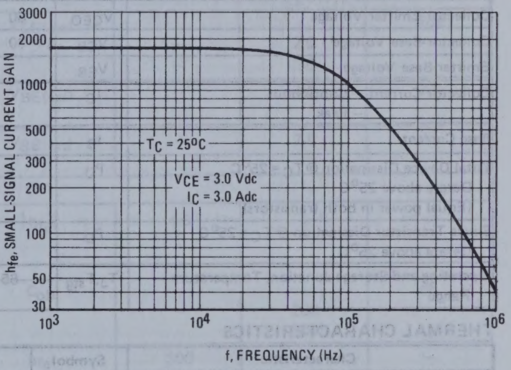


FIGURE 4 – "ON" VOLTAGES

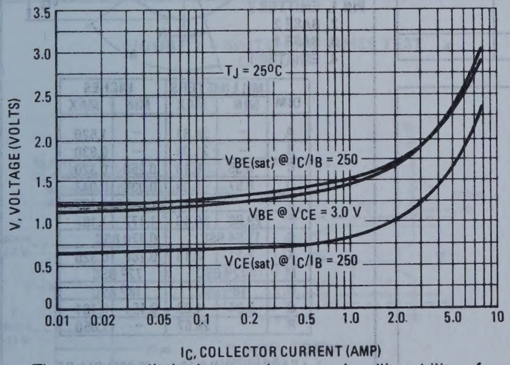
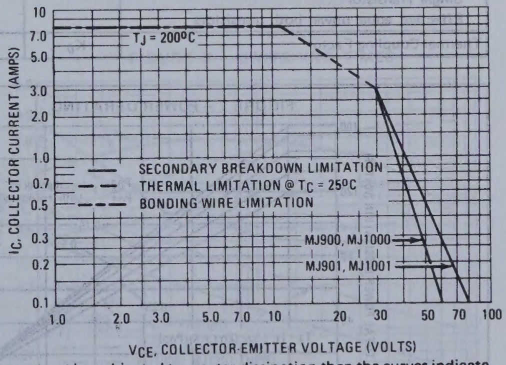


FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

MJ920, MJ921 PNP (SILICON)
MJ1200, MJ1201 NPN

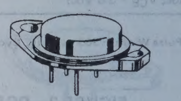
DUAL SILICON POWER DARLINGTON TRANSISTORS

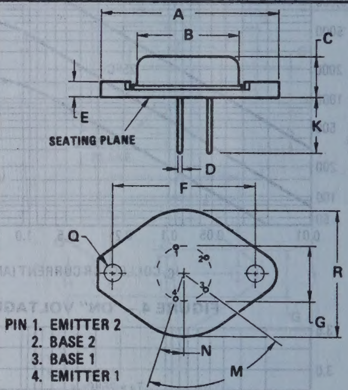
. . . designed for hammer driver, regulator and amplifier applications.

- High DC Current Gain –
  h_{FE} = 3000 (Typ) @ I_C = 4.0 Adc
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 60 Vdc – MJ920, MJ1200
  = 80 Vdc – MJ921, MJ1201
- Total Monolithic Construction
  Dual transistors in the same chip, yielding like electrical characteristics. Collectors are common

DUAL DARLINGTON
8 AMPERE
COMPLEMENTARY SILICON
POWER TRANSISTORS

60, 80 VOLTS
160 WATTS





PIN 1. EMITTER 2
2. BASE 2
3. BASE 1
4. EMITTER 1

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	38.61	–	1.520
B	–	21.08	–	0.830
C	6.35	8.13	0.250	0.320
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	11.94 BSC		0.470 BSC	
K	7.11	8.13	0.280	0.320
M	72° BSC		72° BSC	
N	18° BSC		18° BSC	
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) DIA OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

CASE 253

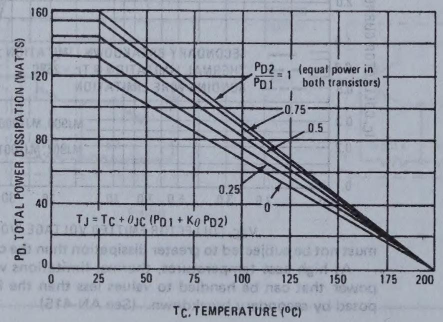
MAXIMUM RATINGS

Rating	Symbol	MJ920 MJ1200	MJ921 MJ1201	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous – Peak	I_C	8.0 16		Adc
Base Current	I_B	120		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C (Equal power in both transistors)	P_D	160 0.91		Watts W/°C
Single Transistor Dissipation @ T_C = 25°C Derate above 25°C	P_D	120 0.68		Watts W/°C
Operating and Storage Junction, Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case Single Transistor Effective, equal power both transistors	θ_{JC}	 1.46 1.10	°C/W
Thermal Coupling Factor	K_θ	50	%

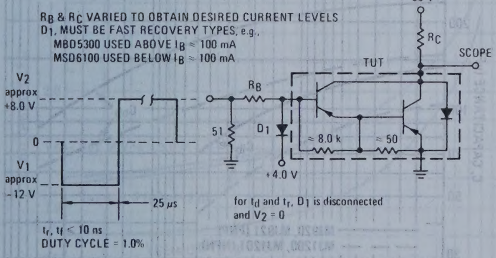
FIGURE 1 – POWER DERATING



ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 100$ mAdc, $I_B = 0$)	 MJ920, MJ1200 MJ921, MJ1201	$V_{CEO(sus)}$	 60 80	 – –	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $I_B = 0$) ($V_{CE} = 40$ Vdc, $I_B = 0$)	 MJ920, MJ1200 MJ921, MJ1201	I_{CEO}	 – –	 0.5 0.5	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CB}, $V_{BE(off)} = 1.5$ Vdc) (V_{CE} = Rated V_{CB}, $V_{EB(off)} = 1.5$ Vdc) (V_{CE} = Rated V_{CB}, $V_{BE(off)} = 1.5$ Vdc, $T_C = 150^oC$) (V_{CE} = Rated V_{CB}, $V_{EB(off)} = 1.5$ Vdc, $T_C = 150^oC$)	 MJ920, MJ921 MJ1200, MJ1201 MJ920, MJ921 MJ1200, MJ1201	I_{CEX}	 – – – –	 0.5 0.5 5.0 5.0	mAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 4.0$ Adc, $V_{CE} = 3.0$ Vdc) ($I_C = 8.0$ Adc, $V_{CE} = 3.0$ Vdc)		h_{FE}	 750 100	 18000 –	–
Collector-Emitter Saturation Voltage ($I_C = 4.0$ Adc, $I_B = 16$ mAdc) ($I_C = 8.0$ Adc, $I_B = 80$ mAdc)		$V_{CE(sat)}$	 – –	 2.0 3.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 8.0$ Adc, $I_B = 80$ mAdc)		$V_{BE(sat)}$	–	4.0	Vdc
Base-Emitter On Voltage ($I_C = 4.0$ Adc, $V_{CE} = 3.0$ Vdc)		$V_{BE(on)}$	–	2.8	Vdc
DYNAMIC CHARACTERISTICS					
Magnitude of Common Emitter Small-Signal Short Circuit Forward Current Transfer Ratio ($I_C = 3.0$ Adc, $V_{CE} = 3.0$ Vdc, f = 1.0 MHz)		$\|h_{fe}\|$	4.0	–	–
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 0.1 MHz)	MJ1200, MJ1201 MJ920, MJ921	C_{ob}	– –	200 300	pF
Small-Signal Current Gain ($I_C = 3.0$ Adc, $V_{CE} = 3.0$ Vdc, f = 1.0 kHz)		h_{fe}	300	–	–

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT


V_{CC}
-30 V
R_B & R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS
D_1, MUST BE FAST RECOVERY TYPES, e.g.,
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA
R_C
SCOPE
TUT
V_2
approx
+8.0 V
R_B
0
51
D_1
≈ 8.0 k
≈ 50
V_1
approx
-12 V
+4.0 V
25 μs
for t_d and t_r, D_1 is disconnected and $V_2 = 0$
t_r, $t_f \leq 10$ ns
DUTY CYCLE = 1.0%

For NPN test circuit, reverse all polarities.

FIGURE 3 – SWITCHING TIMES

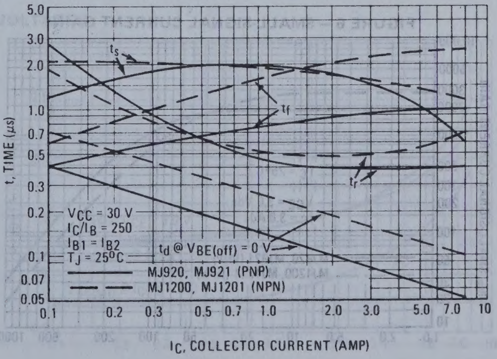


FIGURE 4 – THERMAL RESPONSE

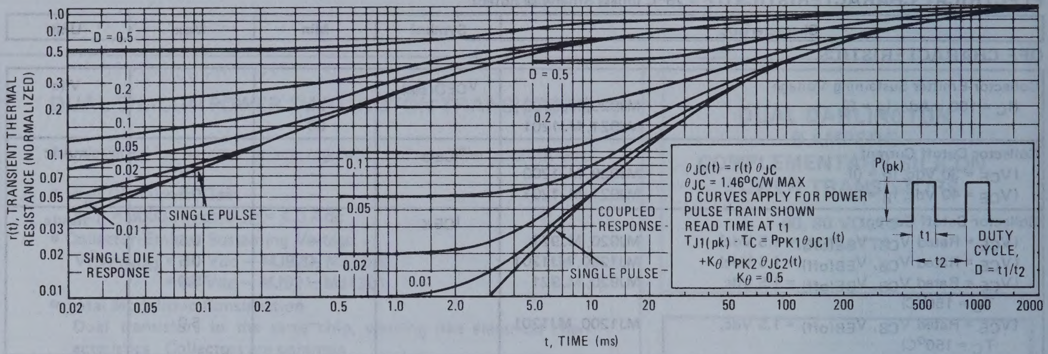
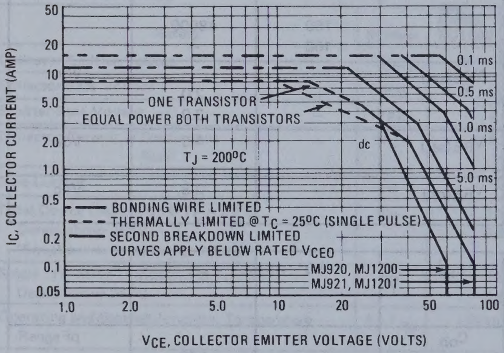


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



NOTE

Computing Peak Junction Temperature

Use $T_{J1(pk)} - T_C = P_{PK1}\theta_{JC1}(t) + K_\theta P_{PK2}\theta_{JC2}(t)$

Example: $P_{PK1} = 200$ W, $t_1 = 5.0$ ms, $D = 20\%$; $P_{PK2} = 100$ W, $t_1 = 10$ ms, $D = 20\%$ } Pulses Coincident at Trailing Edge

Read $r(t) = 0.55$; Read $r(t) = 0.21$ (from Figure 4)

$\therefore \theta_{JC1(t)} = 0.80$; $\therefore \theta_{JC2(t)} = 0.31$

$$T_{J1(pk)} - T_C = (200)(0.8) + (0.5)(100)(0.31)$$
$$= 160 + 15 = 175^\circ C$$

Where the side having highest junction temperature is not obvious, both sides should be checked.

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – SMALL-SIGNAL CURRENT GAIN

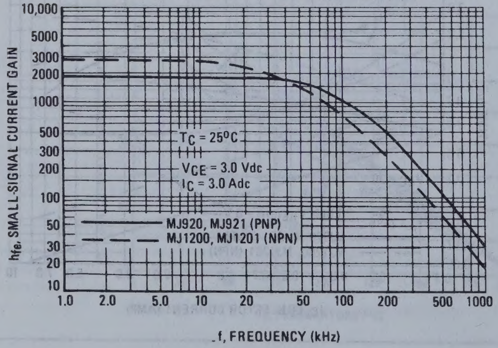
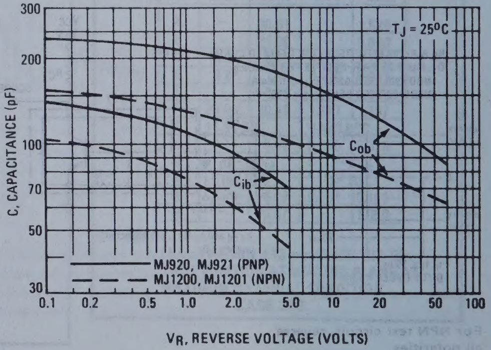


FIGURE 7 – CAPACITANCE



PNP
MJ920, MJ921

NPN
MJ1200, MJ1201

FIGURE 8 – DC CURRENT GAIN

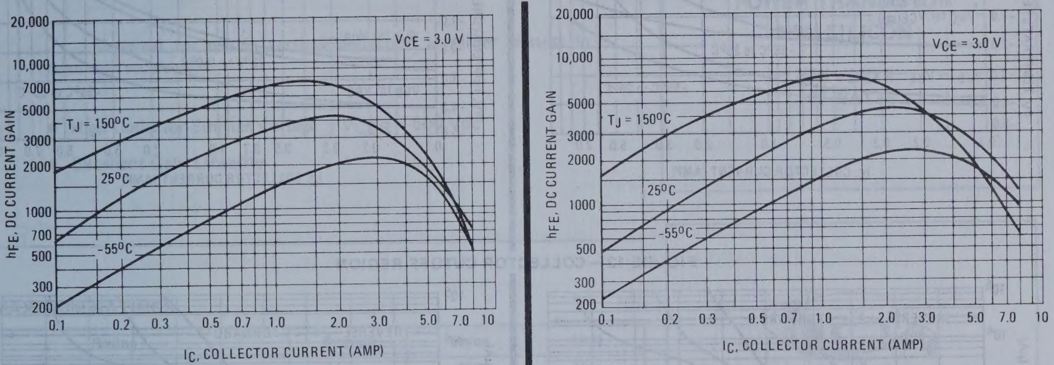


FIGURE 9 – COLLECTOR SATURATION REGION

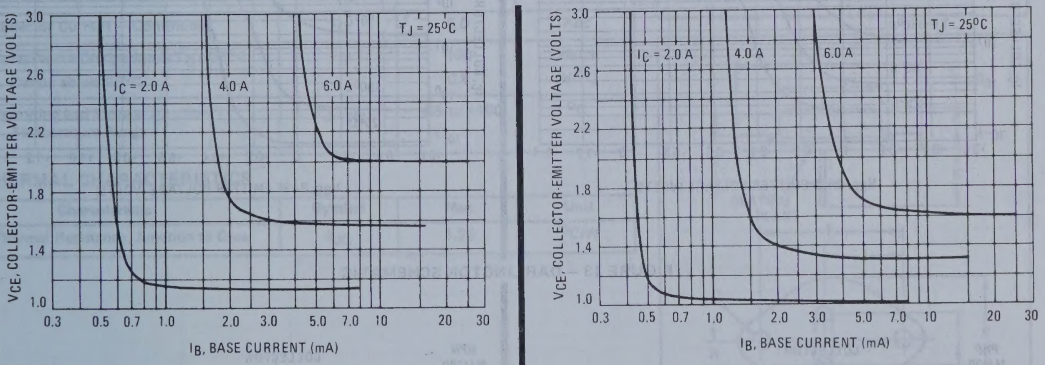
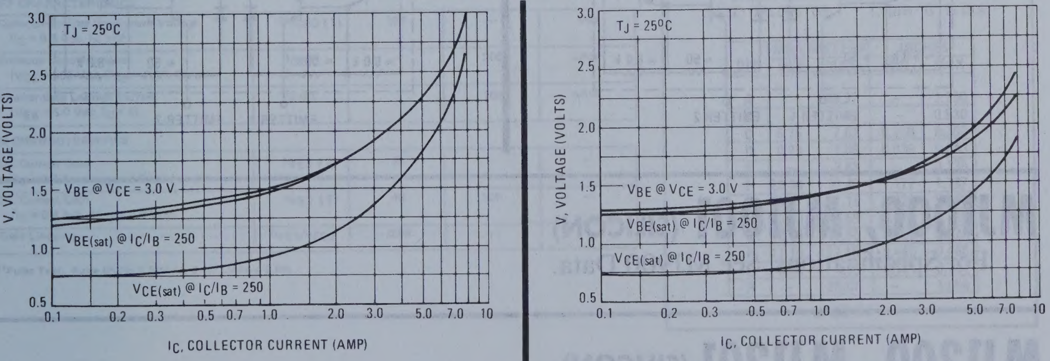


FIGURE 10 – ON VOLTAGES



PNP
MJ920, MJ921

NPN
MJ1200, MJ1201

FIGURE 11 – TEMPERATURE COEFFICIENTS

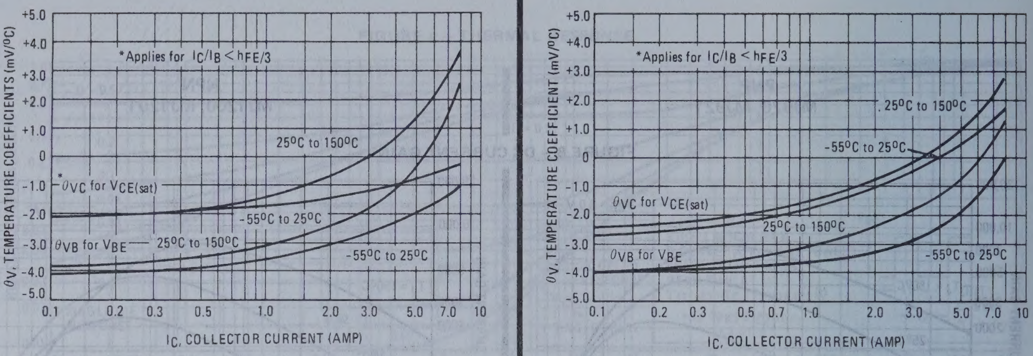


FIGURE 12 – COLLECTOR CUTOFF REGION

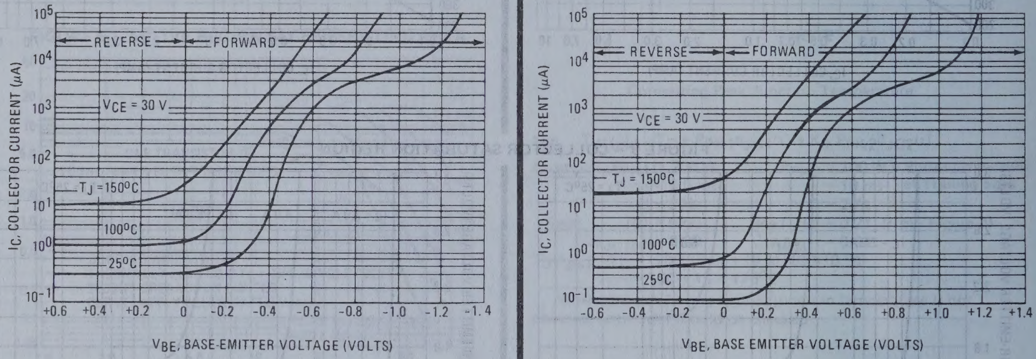
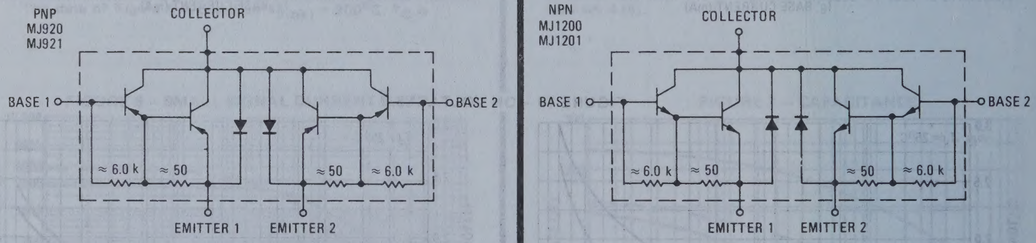


FIGURE 13 – DARLINGTON SCHEMATIC


PNP
MJ920
MJ921
COLLECTOR
BASE 1
BASE 2
≈ 6.0 k
≈ 50
≈ 50
≈ 6.0 k
EMITTER 1
EMITTER 2
NPN
MJ1200
MJ1201
COLLECTOR
BASE 1
BASE 2
≈ 6.0 k
≈ 50
≈ 50
≈ 6.0 k
EMITTER 1
EMITTER 2

MJ1000, MJ1001 (SILICON)

For Specifications, See MJ900 Data.

MJ1200, MJ1201 (SILICON)

For Specifications, See MJ920 Data.

MJ1800 (SILICON)

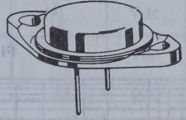
HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in vertical deflection amplifier circuits in television receivers.

- High Collector-Emitter Voltage – V_{CER} = 500 Vdc
- Excellent Gain Linearity

5 AMPERES
POWER TRANSISTOR
NPN SILICON

500 VOLTS
100 WATTS

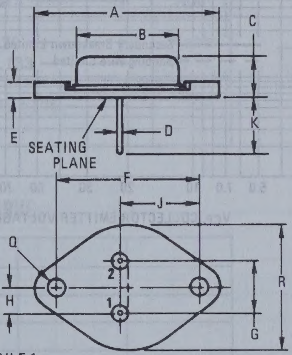


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Emitter Voltage	V_{CER}	500	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	100 0.8	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	BV_{CEO} (1)	250	–	Vdc
Collector Cutoff Current (V_{CE} = 500 Vdc, R_{BE} = 1.5 k Ohms)	I_{CER}	–	200	μAdc
Emitter-Base Leakage Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc)	h_{FE1} (1)	35	–	–
DC Current Gain (I_C = 0.4 Adc, V_{CE} = 5.0 Vdc)	h_{FE2} (1)	40	120	–
Gain Linearity	h_{FE1}/h_{FE2}	0.95	–	–

(1) Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE

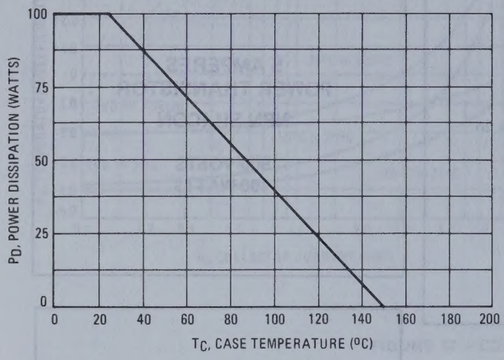


FIGURE 2 – NORMALIZED DC CURRENT GAIN

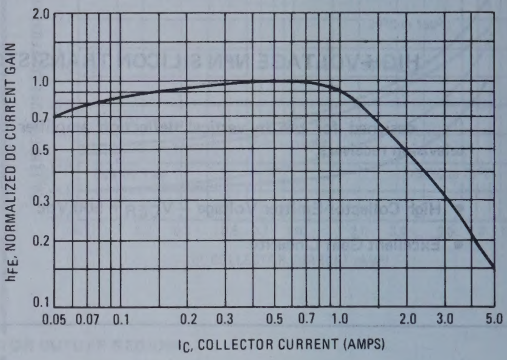
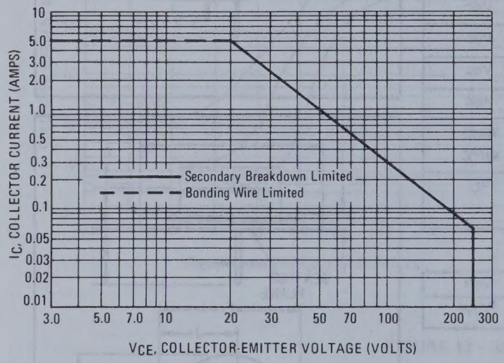


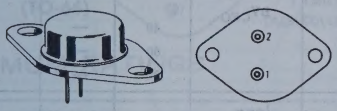
FIGURE 3 – ACTIVE-REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ2249 (SILICON)
MJ2250
MJ3101

Medium-power NPN silicon transistors ideal for use as drivers, switches, amplifiers.



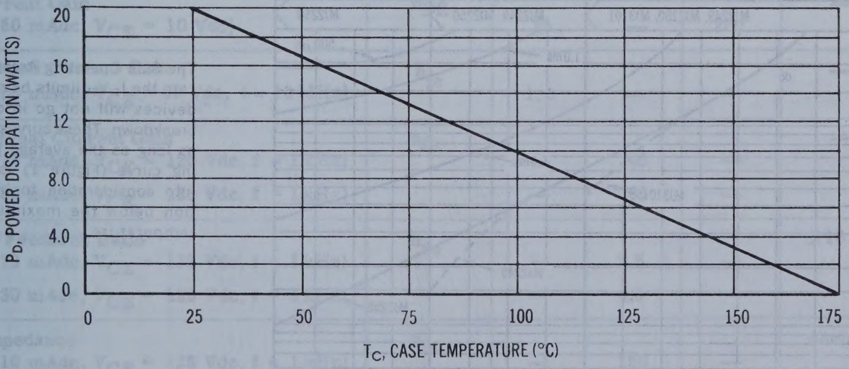
CASE 80
(TO-66)

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	MJ3101	MJ2249	MJ2250	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current - Continuous Peak	I_C	← 2.0 → ← 3.0 →			Adc
Base Current	I_B	← 0.5 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 20 → ← 0.133 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →			°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



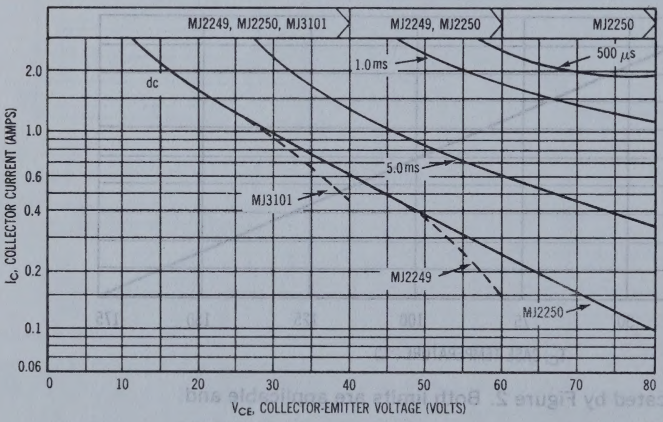
Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage (1) (I_C = 100 mAdc, I_B = 0)	MJ3101	BV_{CEO}	40	—	Vdc
	MJ2249		60	—	
	MJ2250		80	—	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 50 Vdc, I_E = 0)	MJ3101			1.0	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 60 Vdc, I_E = 0)	MJ2249		—	1.0	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	MJ2250		—	1.0	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
Emitter-Base Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	All Types	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 50 mAdc, V_{CE} = 4.0 Vdc)	All Types		25	—	
(I_C = 100 mAdc, V_{CE} = 4.0 Vdc)†	All Types		25	200	
(I_C = 500 mAdc, V_{CE} = 4.0 Vdc)*	All Types		25*	200*	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	1.0	
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	2.5	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ2249, MJ2250		—	2.5	
Base-Emitter Saturation Voltages		$V_{BE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	1.2	
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	1.5	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ2249, MJ2250		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)	All Types	f_T	10	—	MHz

(1) PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2.0% †Color coded h_{FE} groups available at 100 mAdc

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

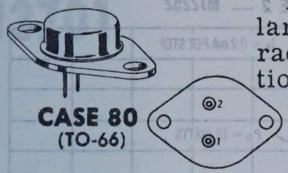


The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. These curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

NOTE: For additional design curves, please refer to Type 2N3766.

MJ2251 (SILICON)
MJ2252

High-voltage NPN silicon power transistors, particularly well suited for power output stages in television, radio, phonograph and other consumer product applications.



CASE 80
(TO-66)

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MJ2251 MJ2252	V_{CEO}	 225 300	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_C = 70°C Derate above 70°C	P_D	 10 0.125	 Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T$_A$ = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0) MJ2251 MJ2252	BV_{CEO}	225 300	— —	— —	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	—	—	100	µAdc
Emitter-Base Leakage Current (V_{EB} = 6 Vdc, I_C = 0)	I_{EBO}	—	—	100	µAdc
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	200	—
Small Signal Current Gain (I_C = 20 mAdc, V_{CE} = 50 Vdc, f = 10 MHz)	h_{fe}	1.0	—	—	—
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{fe}	— —	40 65	— —	—
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{re}	— —	2.5 4.0	— —	$X10^{-5}$
Input Impedance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{ie}	— —	150 75	— —	ohms
Output Admittance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{oe}	— —	5 20	— —	µmhos

COLLECTOR CHARACTERISTICS

FIGURE 1 — MJ2251

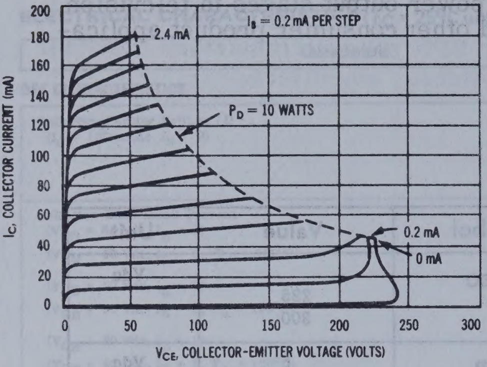


FIGURE 2 — MJ2252

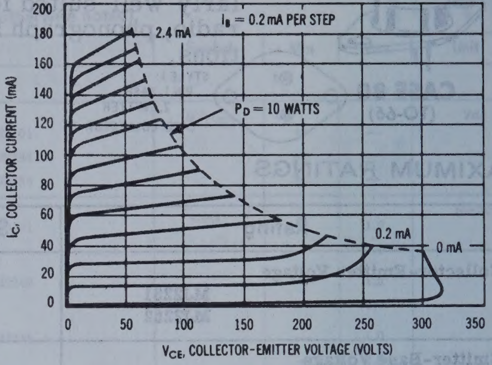


FIGURE 3 — COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

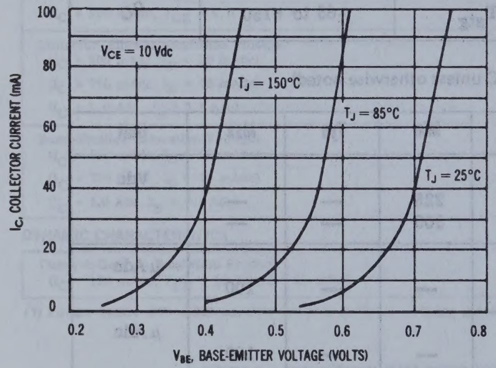


FIGURE 4 — TYPICAL LINE-OPERATED 1.5-WATT AUDIO AMPLIFIER

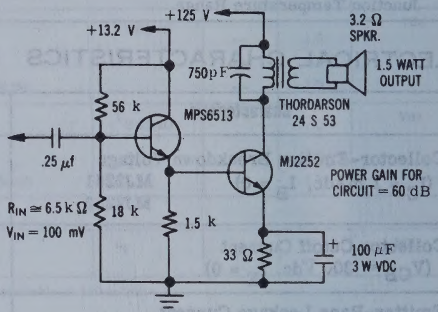

+125 V
+13.2 V
3.2 Ω
SPKR.
1.5 WATT
OUTPUT
750 pF
THORDARSON
24 S 53
56 k
MPS6513
.25 μf
MJ2252
POWER GAIN FOR
CIRCUIT = 60 dB
R_{IN} ≅ 6.5 k Ω
V_{IN} = 100 mV
18 k
1.5 k
33 Ω
100 μF
3 W VDC

FIGURE 5 — TYPICAL TOTAL HARMONIC DISTORTION versus P_{out}

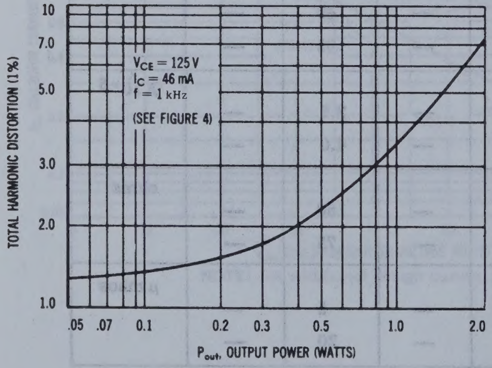
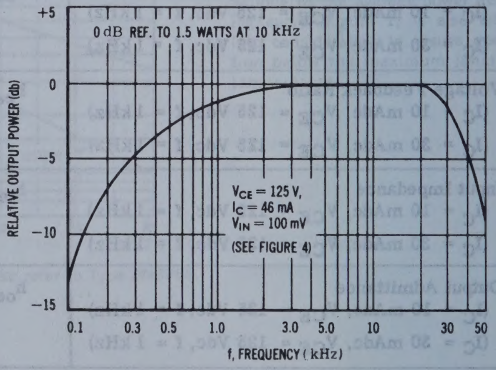


FIGURE 6 — TYPICAL FREQUENCY RESPONSE OF LINE OPERATED AUDIO AMPLIFIER



MJ2253 (SILICON)
MJ2254
MJ3701

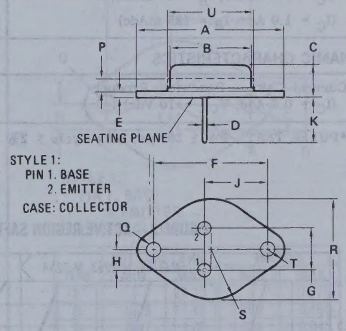
MEDIUM-POWER PNP SILICON TRANSISTORS

. . . ideal for use as drivers, switches, amplifiers and direct replacement of germanium medium-power devices. These devices feature:

- Low Saturation Voltage — 0.6 $V_{CE(sat)}$ @ $I_C = 1.0$ Adc
- $h_{FE} = 15$ (min) @ $I_C = 500$ mAdc
- Excellent Safe-Area Limits (Figure 2)
- $f_T = 3.0$ MHz (min)
- Recommended For Use to $I_C = 1.0$ Adc
- Complementary to Motorola NPN Types: MJ2249, MJ2250, MJ3101

1 AMPERE
POWER TRANSISTORS

PNP SILICON
40-80 VOLTS
25 WATTS



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

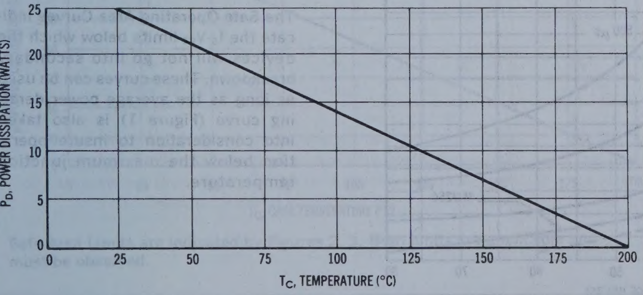
All JEDEC Dimensions and and Notes Apply.

CASE 80-02
TO-66

MAXIMUM RATINGS

Characteristics	Symbol	MJ3701	MJ2253	MJ2254	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	70	90	Vdc
Emitter-Base Voltage	V_{EB}	5	7	7	Vdc
Collector Current - Continuous Peak	I_C		3.0 4.0		Adc
Base Current	I_B		0.5		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D		25 0.143		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}		-65 to +200		^oC

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.

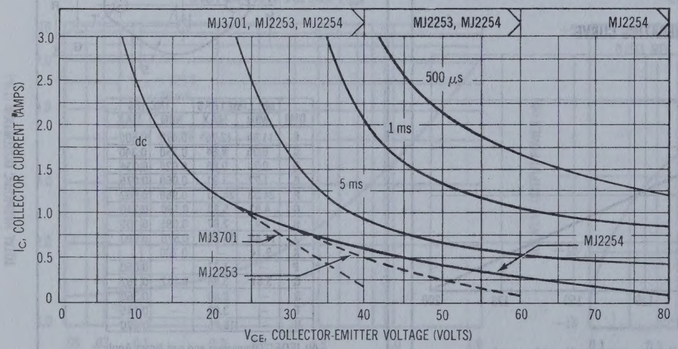
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	MJ3701	$V_{CEO(sus)}$*	40	—	Vdc
	MJ2253		60	—	
	MJ2254		80	—	
Collector-Base Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	MJ3701	I_{CBO}	—	1.0	mAdc
(V_{CB} = 70 Vdc, I_E = 0)	MJ2253		—	1.0	
(V_{CB} = 90 Vdc, I_E = 0)	MJ2254		—	1.0	
(V_{CB} = 40 Vdc, I_E = 0, T_C = 150°C)	MJ3701		—	2.0	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJ2253		—	2.0	
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJ2254		—	2.0	
Emitter-Base Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)	MJ3701	I_{EBO}	—	2.0	mAdc
(V_{BE} = 7 Vdc, I_C = 0)	MJ2253, MJ2254		—	1.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 4 Vdc)†	All Types	h_{FE}	20	—	—
(I_C = 250 mAdc, V_{CE} = 4 Vdc)	All Types		20	100	
(I_C = 500 mAdc, V_{CE} = 4 Vdc)*	All Types		15	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{CE(sat)}$	—	0.3	Vdc
(I_C = 1.0 Adc, I_B = 125 mAdc)	All Types		—	0.8	
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{BE(sat)}$	—	1.2	Vdc
(I_C = 1.0 Adc, I_B = 125 mAdc)	All Types		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)	All Types	f_T	3.0	—	MHz

*PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2%

†Color coded h_{FE} groups available at 100 mAdc

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. These curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

NOTE: For additional design curves, please refer to Type 2N3740, Motorola DS 3071.

MJ2267 (SILICON)
MJ2268

PNP SILICON POWER TRANSISTORS

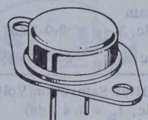
. . . designed for medium-speed switching and high-power amplifier applications. These devices can be directly substituted for germanium types.

- Low $V_{CE(sat)} = 1.0$ Vdc (Max) @ $I_C = 4.0$ Adc
- $f_r = 3.0$ MHz (Min)
- $h_{FE} = 20\text{-}100$ @ $I_C = 4.0$ Adc
- Excellent Safe Area Limits (Figures 2 and 3)
- Recommended For Use to $I_C = 4.0$ Adc

5 AMPERES
POWER TRANSISTORS

PNP SILICON

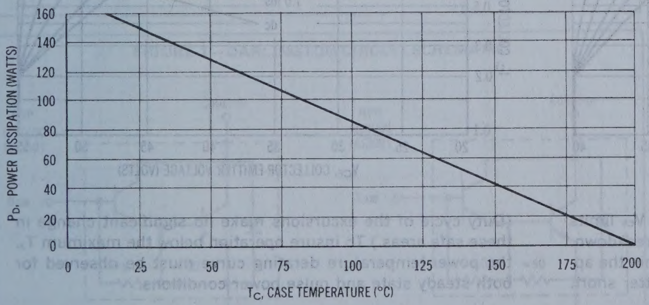
40-55 VOLTS
150 WATTS



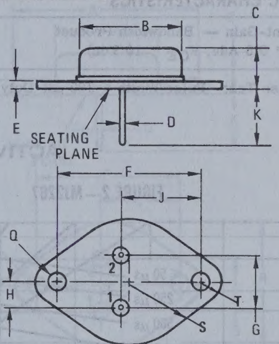
MAXIMUM RATINGS

Characteristic	Symbol	MJ2267	MJ2268	Unit
Collector-Emitter Voltage	V_{CEO}	40	55	Vdc
Collector-Base Voltage	V_{CB}	40	55	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector Current - Continuous	I_C	5.0		Adc
Base Current	I_B	3		Adc
Power Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	150 0.86		Watts $W/^{\circ}C$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^{\circ}C$

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figures 2, 3. Both limits are applicable and must be observed.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	–	0.312	–
Q	3.84	4.09	0.151	0.161
S	–	13.34	–	0.525
T	–	4.78	–	0.188

All JEDEC dimensions and notes apply

CASE 1-03
(TO-3)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

OFF CHARACTERISTICS

Characteristics		Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	MJ2267	$V_{CEO(sus)}$	40	—	Vdc
	MJ2268		55	—	
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc)	MJ2267	I_{CEX}	—	1.0	mAdc
(V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	MJ2268		—	1.0	
(V_{CE} = 20 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2267		—	5.0	
(V_{CE} = 30 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2268		—	5.0	
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	5.0	mAdc

ON CHARACTERISTICS

Characteristics		Symbol	Min	Max	Unit
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	Both Types	h_{FE}	20	—	—
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)(1)	Both Types		20	100	
Collector-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc)	Both Types	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc)	Both Types	$V_{BE(sat)}$	—	1.5	Vdc

DYNAMIC CHARACTERISTICS

Characteristics		Symbol	Min	Max	Unit
Current-Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)		f_T	3.0	—	MHz

(1) Pulse Test: Pulse Width ≦ 300 µs, Duty Cycle ≦ 2.0%.

ACTIVE REGION SAFE OPERATING AREAS

FIGURE 2 — MJ2267

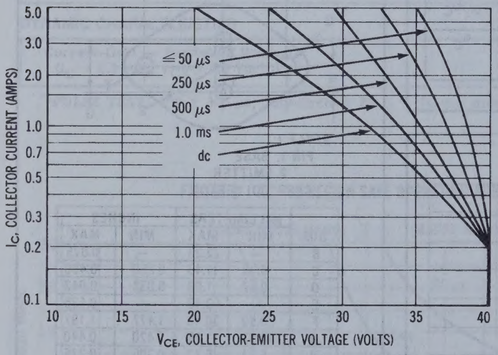
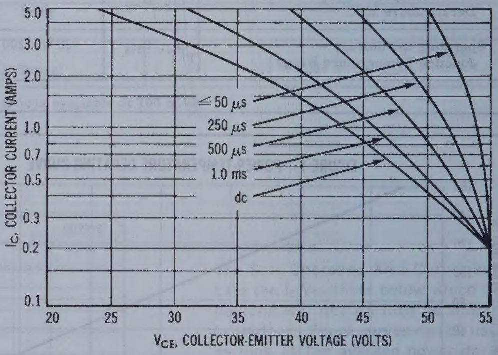


FIGURE 3 — MJ2268



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

NOTE: For additional design curves, please refer to Type 2N3789.

MJ2500, MJ2501 PNP (SILICON)
MJ3000, MJ3001 NPN

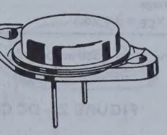
MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

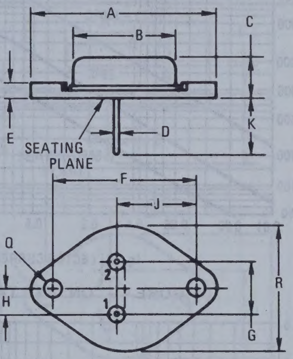
. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain – h_{FE} = 4000 (Typ) @ I_C = 5.0 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistors

10 AMPERE
DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON

60–80 VOLTS
150 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

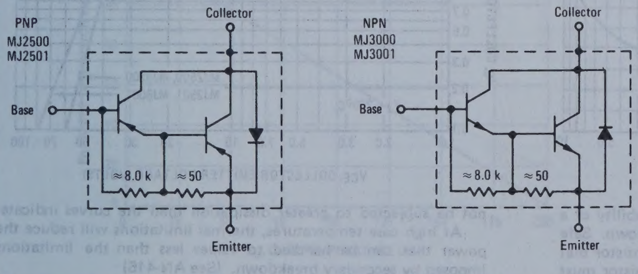
MAXIMUM RATINGS

Rating	Symbol	MJ2500 MJ3000	MJ2501 MJ3001	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	10		Adc
Base Current	I_B	0.2		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	150 0.857		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC



ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)		BV_{CEO}			Vdc
(I_C = 100 mAdc, I_B = 0)	MJ2500, MJ3000		60	–	
	MJ2501, MJ3001		80	–	
Collector Emitter Leakage Current		I_{CER}			mAdc
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm)	MJ2500, MJ3000		–	1.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm)	MJ2501, MJ3001		–	1.0	
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm, $T_C = 150^oC$)	MJ2500, MJ3000		–	5.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm, $T_C = 150^oC$)	MJ2501, MJ3001		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
Collector-Emitter Leakage Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ2500, MJ3000		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	MJ2501, MJ3001		–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	1000	–	–
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 5.0 Adc, I_B = 20 mAdc)			–	2.0	
(I_C = 10 Adc, I_B = 50 mAdc)			–	4.0	
Base-Emitter Voltage (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	3.0	Vdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

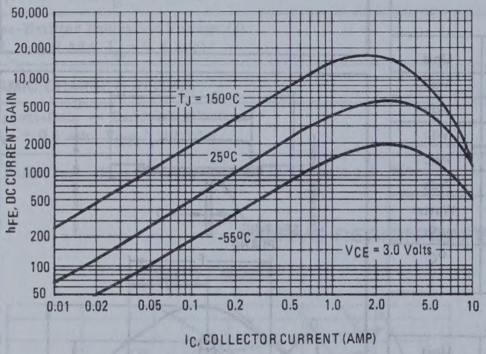


FIGURE 3 – SMALL-SIGNAL CURRENT GAIN

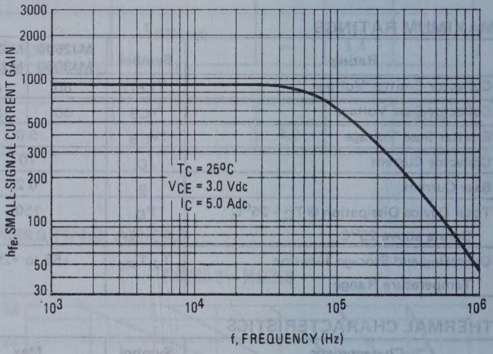


FIGURE 4 – "ON" VOLTAGES

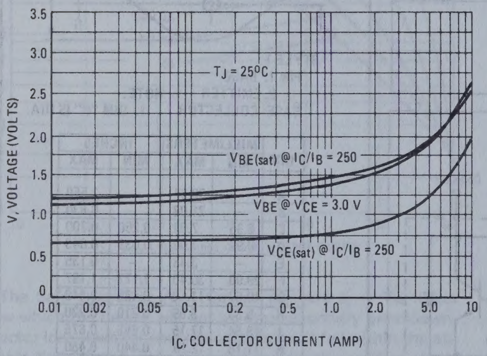
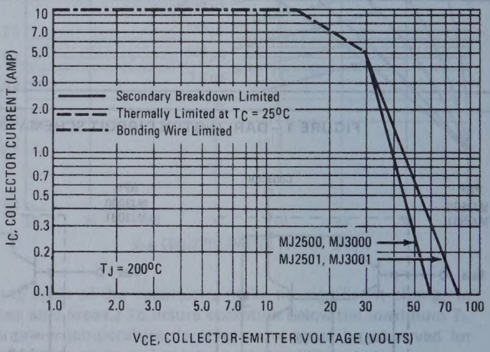


FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

MJ2801 NPN (SILICON)
MJ2901 PNP

COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed for general-purpose amplifier and switching circuit applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.5 Vdc (Max) @ I_C = 8.0 Adc
- DC Current Gain –
  h_{FE} = 15 (Min) @ I_C = 8.0 Adc

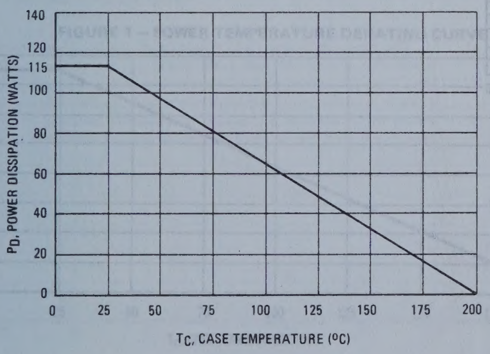
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	15	Adc
Base Current	I_B	7.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	115 0.657	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

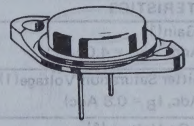
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	$^oC/W$

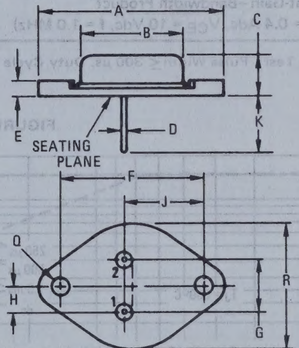
FIGURE 1 – POWER TEMPERATURE DERATING CURVE



15 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

40 VOLTS
115 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

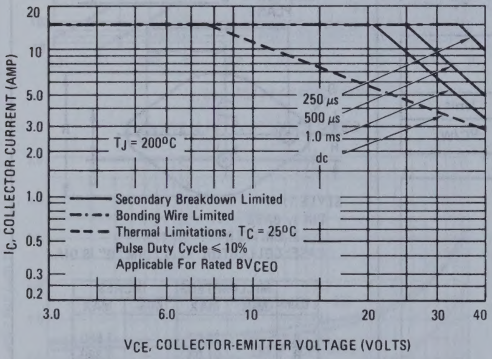
CASE 11

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	40	–	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	5.0	mAdc
Collector Cutoff Current	I_{CBO}			mAdc
(V_{CB} = 50 Vdc, I_E = 0)		–	5.0	
(V_{CB} = 50 Vdc, I_E = 0, T_C = 150°C)		–	10	
Emitter Cutoff Current (V_{EB} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	15	60	–
Collector-Emitter Saturation Voltage(1) (I_C = 8.0 Adc, I_B = 0.8 Adc)	$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter On Voltage(1) (I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	2.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 0.4 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	1.0	–	MHz

(1)Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.

FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ2840 (SILICON)
MJ2841

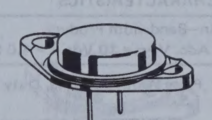
HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain —
  h_{FE} = 20 - 100 @ I_C = 3.0 Adc (MJ2840)
  = 4.0 Adc (MJ2841)
- Complement to PNP MJ2940 and MJ2941

10 AMPERE
POWER TRANSISTORS

NPN SILICON
60–80 VOLTS
150 WATTS



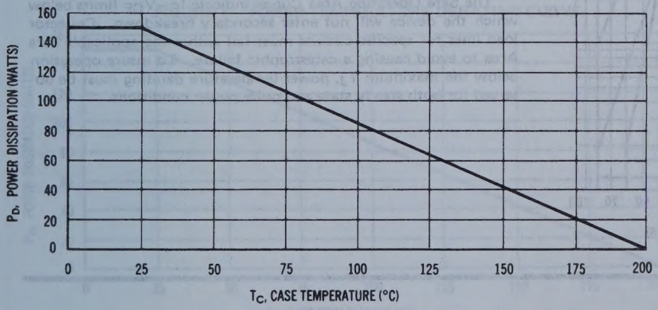
MAXIMUM RATINGS

Rating	Symbol	MJ2840	MJ2841	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.85		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

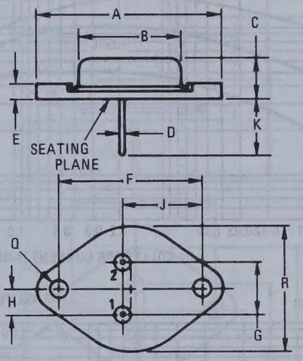
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

ELECTRICAL CHARACTERISTIC (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	MJ2840 MJ2841	$V_{CEO(sus)}$	60 80	– –	Vdc
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0) (V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)	Both Types Both Types	I_{CBO}	0.1 2.0	– –	mAdc
Base-Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	Both Types	I_{EBO}	1.0	–	mAdc
ON CHARACTERISTICS					
DC Current Gain[1] (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	Both Types MJ2840 MJ2841	h_{FE}	40 20 20	– 100 100	–
Base-Emitter On Voltage[1] (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2840 MJ2841	$V_{BE(on)}$	– –	1.3 1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	20	MHz

[1] Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

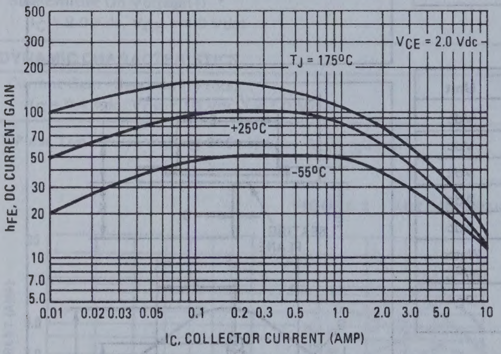


FIGURE 3 – "ON" VOLTAGES

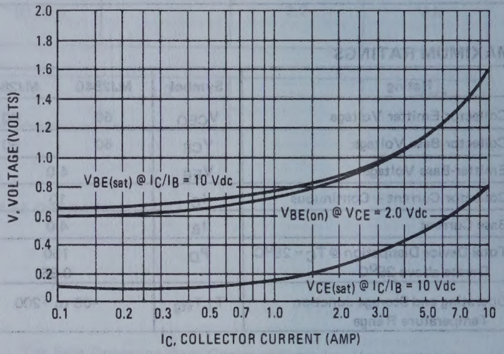
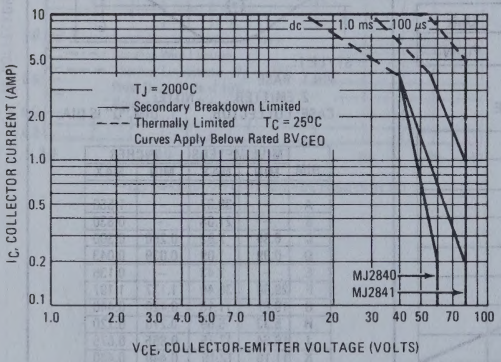


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C—V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ2901 (SILICON)

For Specifications, See MJ2801 Data.

MJ2940 (SILICON)
MJ2941

HIGH-POWER PNP SILICON TRANSISTORS

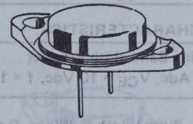
. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain –
  h_{FE} = 20 - 100 @ I_C = 3.0 Adc (MJ2940)
  = 4.0 Adc (MJ2941)
- Complement to NPN MJ2840 and MJ2841

10 AMPERE
POWER TRANSISTORS

PNP SILICON

60–80 VOLTS
150 WATTS



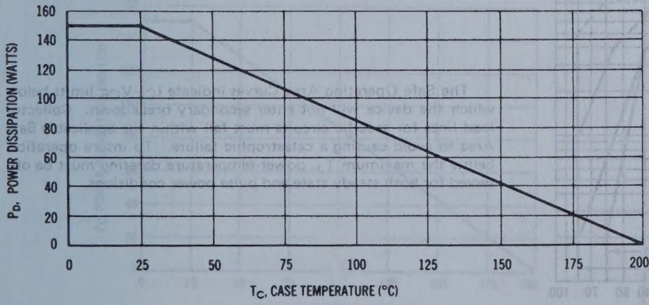
MAXIMUM RATINGS

Rating	Symbol	MJ2940	MJ2941	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^{o}C	P_D	150 0.85		Watts W/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^{o}C

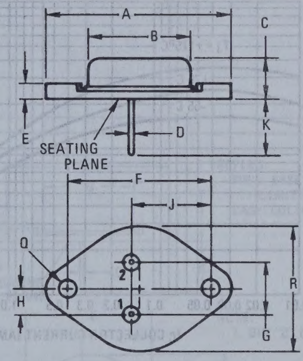
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	^{o}C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

ELECTRICAL CHARACTERISTIC ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	MJ2940 MJ2941	$V_{CEO(sus)}$	60 80	– –	Vdc
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0) (V_{CB} = Rated V_{CB}, I_E = 0, $T_C = 150^oC$)		I_{CBO}	– –	0.1 3.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	 Both Types MJ2940 MJ2941	h_{FE}	 40 20 20	 – 100 100	–
Base-Emitter On Voltage(1) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	 MJ2940 MJ2941	$V_{BE(on)}$	 – –	 1.3 1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		f_T	4.0	20	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

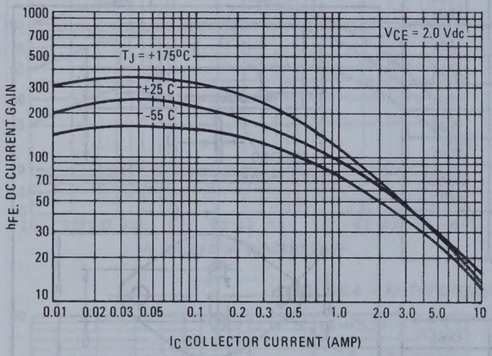


FIGURE 3 – "ON" VOLTAGES

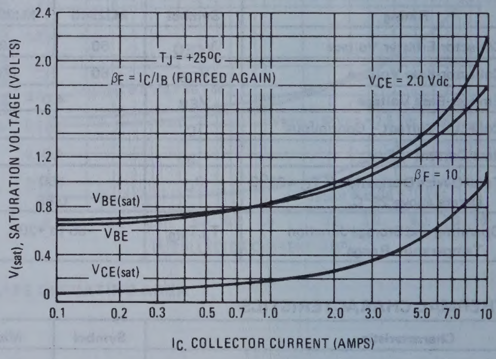
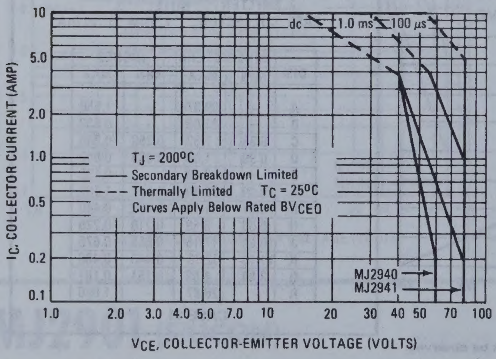


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ2955 (SILICON)

PNP SILICON POWER TRANSISTOR

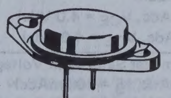
. . . designed for general-purpose switching and amplifier applications.

- DC Current Gain –
  h_{FE} = 20-70 @ I_C = 4.0 Adc
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.1 Vdc (Max) @ I_C = 4.0 Adc
- Excellent Safe Operating Area
- Complement to Motorola's "Epi-Base" Transistor, 2N3055

15 AMPERE
POWER TRANSISTOR

PNP SILICON

60 VOLTS
150 WATTS



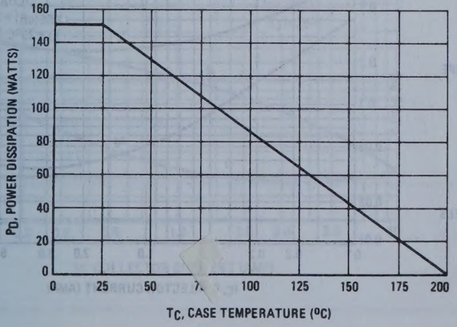
MAXIMUM RATINGS

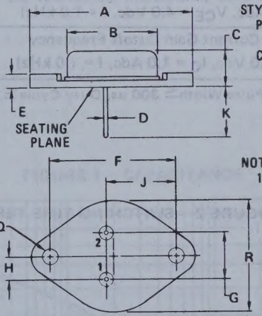
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage	V_{CER}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	15	Adc
Base Current	I_B	7.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}	70	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	0.7	mAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc, $T_C = 150^oC$)	I_{CEX}	– –	1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	20 5.0	70 –	–
Collector-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 400 mAdc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	– –	1.1 3.0	Vdc
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0	–	MHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	h_{fe}	15	–	
Small-Signal Current Gain Cutoff Frequency (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 1.0 kHz)	$f_{\alpha e}$	10	–	kHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

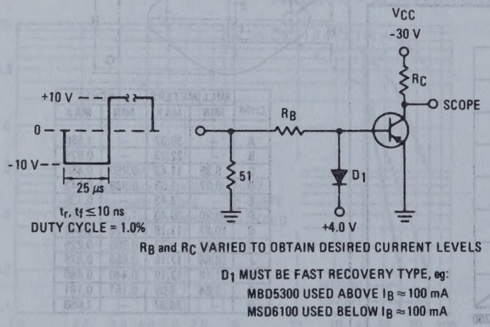
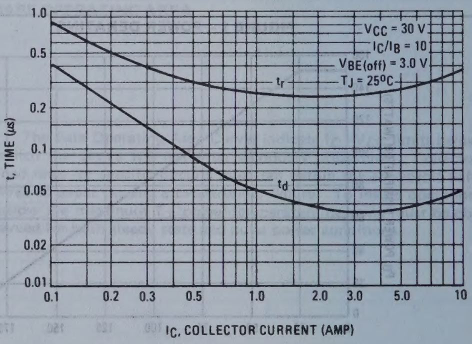

VCC
-30 V
RC
SCOPE
+10 V
0
-10 V
RB
51
D1
25 μs
tr, tf ≤ 10 ns
DUTY CYCLE = 1.0%
+4.0 V
RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS
D1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE IB ≈ 100 mA
MSD6100 USED BELOW IB ≈ 100 mA

FIGURE 3 – TURN-ON TIME



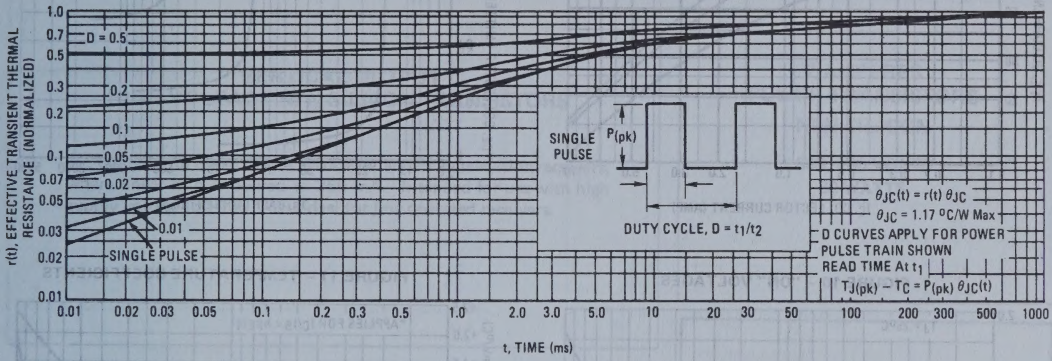


FIGURE 4 – THERMAL RESPONSE

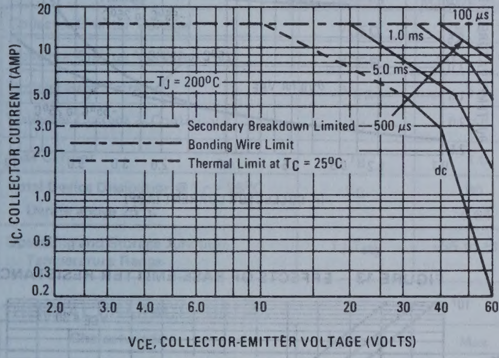


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \approx 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

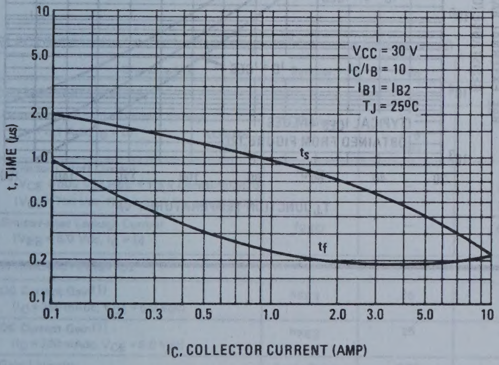


FIGURE 6 – TURN-OFF TIME

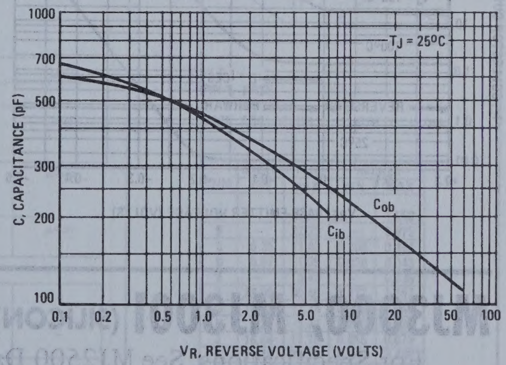


FIGURE 7 – CAPACITANCE

FIGURE 8 – DC CURRENT GAIN

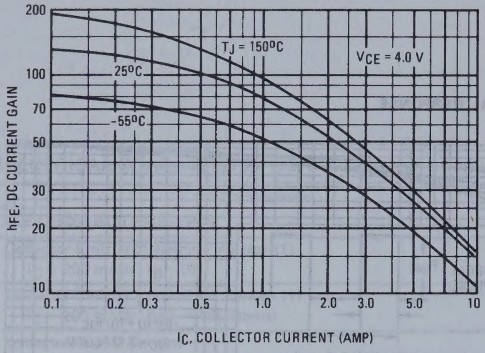


FIGURE 9 – COLLECTOR SATURATION REGION

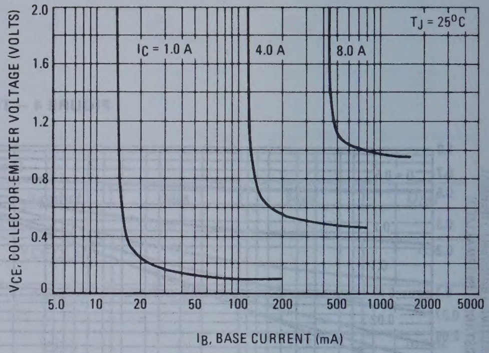


FIGURE 10 – "ON" VOLTAGES

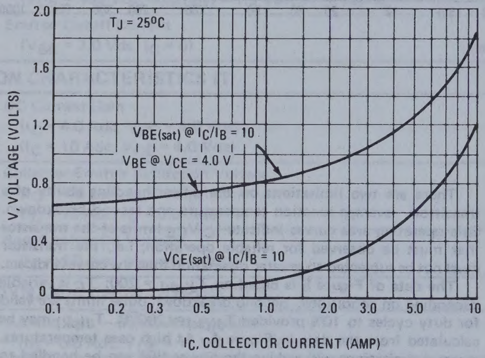


FIGURE 11 – TEMPERATURE COEFFICIENTS

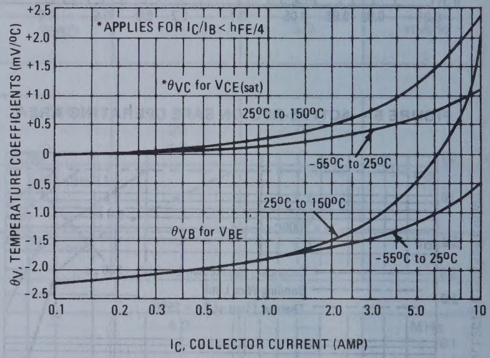


FIGURE 12 – COLLECTOR CUTOFF REGION

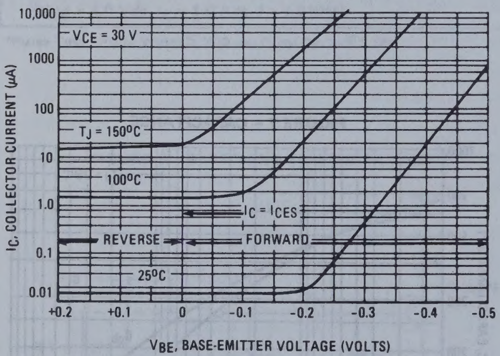
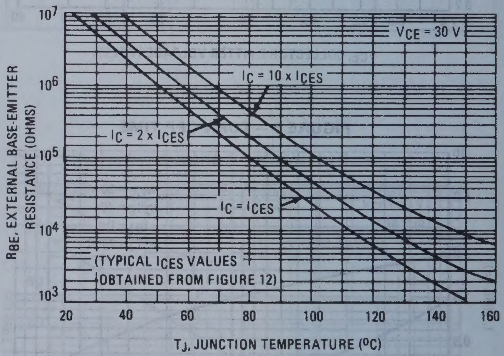


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



MJ3000, MJ3001 (SILICON)

For Specifications, See MJ2500 Data.

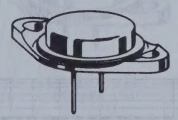
MJ3026 (SILICON)
MJ3027

VERTICAL OUTPUT HIGH-VOLTAGE NPN SILICON TRANSISTORS

. . . designed for use in class A vertical deflection in television receivers, where linear h_{FE} is desired to 250 mA. Intended for use with high supply voltage (80-120 Vdc); ideal for line operated receivers.

2 AMPERES
POWER TRANSISTORS
NPN SILICON

500, 700 VOLTS
80 WATTS

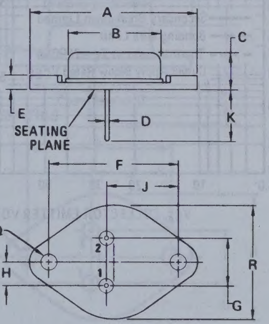


MAXIMUM RATINGS

Rating	Symbol	MJ3026	MJ3027	Unit
Collector-Emitter Voltage	V_{CEO}	275	300	Vdc
Collector-Emitter Voltage	V_{CER}	500	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	80 0.64		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.56	$^oC/W$



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 0.1$ Adc, $I_B = 0$) MJ3026 MJ3027	$V_{CEO(sus)}$	 275 300	 – –	Vdc
Collector Cutoff Current ($V_{CE} = 500$ Vdc, $R_{BE} = 1.5$ k Ohms) MJ3026 ($V_{CE} = 700$ Vdc, $R_{BE} = 1.5$ k Ohms) MJ3027	I_{CER}	 – –	 200 200	μAdc
Emitter-Base Leakage Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	–	500	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 250$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE1}	25	–	–
DC Current Gain(1) ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE2}	25	–	–
Gain Linearity	h_{FE1}/h_{FE2}	0.95	–	–

(1)Pulse Test: Pulse Width ≦ 500 μs, Duty Cycle ≦ 2.0%.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE

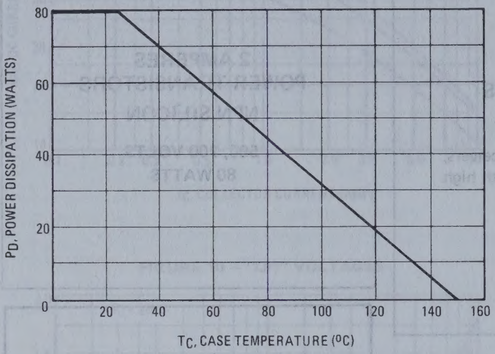


FIGURE 2 – DC CURRENT GAIN

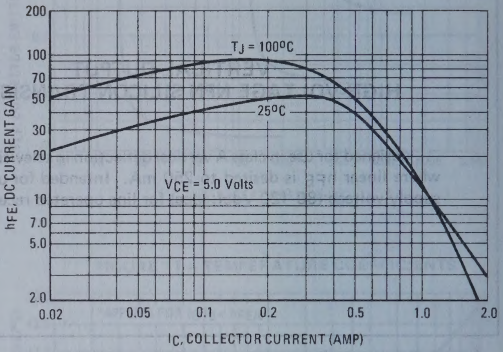
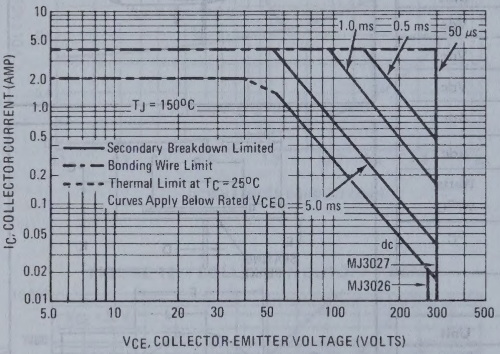


FIGURE 3 – ACTIVE-REGION DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^{\circ}C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

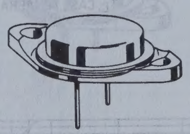
MJ3028 (SILICON)

VERTICAL OUTPUT
HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in class A vertical deflection circuits where linear h_{FE} is desired to 400 mA. Primarily intended for 110° color television receivers.

3.5 AMPERES
POWER TRANSISTOR
NPN SILICON

700 VOLTS
100 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Emitter Voltage	V_{CER}	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	3.5	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25°C	P_D	100 0.8	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

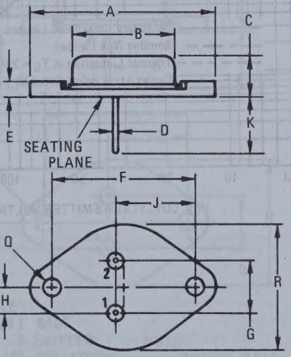
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 0.1$ Adc, $I_B = 0$)	$V_{CEO(sus)}$	300	–	Vdc
Collector Cutoff Current ($V_{CE} = 700$ Vdc, $R_{BE} = 1.5$ k Ohms)	I_{CER}	–	200	µAdc
Emitter-Base Leakage Current ($V_{EB} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	–	500	µAdc
ON CHARACTERISTICS				
DC Current Gain* ($I_C = 0.3$ Adc, $V_{CE} = 5.0$ Vdc)	h_{FE1}*	25	–	–
DC Current Gain* ($I_C = 0.4$ Adc, $V_{CE} = 5.0$ Vdc)	h_{FE2}*	30	–	–
Gain Linearity	h_{FE2}/h_{FE1}	0.95	–	–

*Pulse Test: Pulse Width ≤ 500 µs, Duty Cycle ≤ 2.0%.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

FIGURE 1 – POWER-TEMPERATURE DERATING

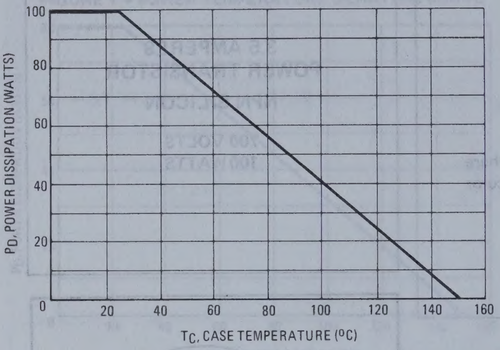


FIGURE 2 – DC CURRENT GAIN

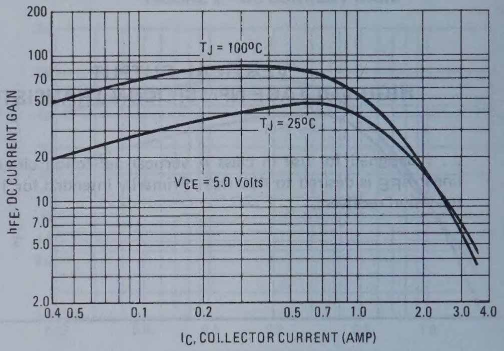
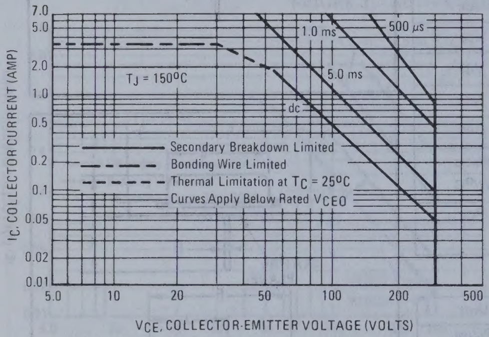


FIGURE 3 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJ3029 (SILICON)
MJ3030

NPN SILICON HIGH-VOLTAGE TRANSISTORS

. . . designed for TV horizontal and vertical deflection amplifier circuits.

- High Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 250 Vdc (Min) MJ3029
  325 Vdc (Min) MJ3030
- Fast Fall Time in Horizontal Deflection —
  t_f = 1.0 μs (Max) @ V_{CC} = 80 Vdc — MJ3030
- Excellent Gain Linearity for Vertical Deflection —
  h_{fe} @ 0.4 Adc, h_{fe} @ 0.3 Adc = 0.95 (Min) — MJ3029

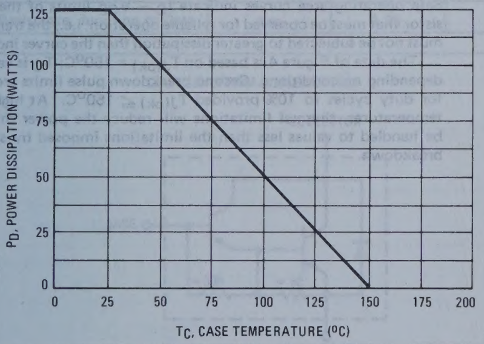
MAXIMUM RATINGS

Rating	Symbol	MJ3029	MJ3030	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Emitter Voltage	V_{CER}	500	—	Vdc
Collector-Emitter Voltage	V_{CEX}	—	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

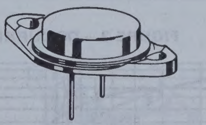
THERMAL CHARACTERISTICS

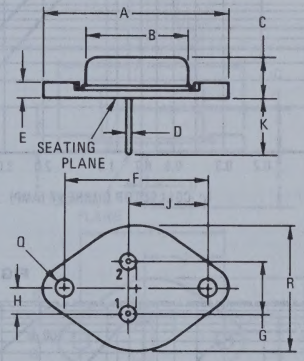
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



5 AMPERE
POWER TRANSISTORS
NPN SILICON
250–325 VOLTS
125 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

MJ3029, MJ3030 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 0.1 Adc, I_B = 0) MJ3029 MJ3030	$V_{CEO(sus)}$	250 325	– –	Vdc
Collector Cutoff Current (V_{CE} = 500 Vdc, R_{BE} = 1.5 k Ohms) MJ3029	I_{CER}	–	1.0	mAdc
Collector Cutoff Current (V_{CE} = 700 Vdc, $V_{EB(off)}$ = 1.5 Vdc) MJ3030	I_{CEX}	–	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc)(1) MJ3029 (I_C = 0.4 Adc, V_{CE} = 5.0 Vdc)(1) MJ3029	h_{FE1} h_{FE2}	25 30	– –	–
Gain Linearity MJ3029	$\frac{h_{FE2}}{h_{FE1}}$	0.95	–	–
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.8 Adc) MJ3030	$V_{CE(sat)}$	–	2.0	Vdc
SWITCHING CHARACTERISTICS				
Fall Time (V_{CC} = 80 Vdc, I_C = 3.0 Adc, I_{B1} = 0.8 Adc) Figure 3 MJ3030	t_f	–	1.0	µs

(1)Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 2 — DC CURRENT GAIN

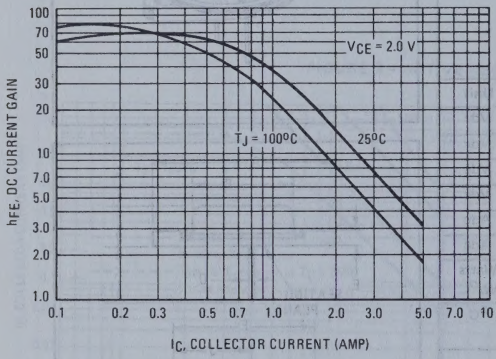
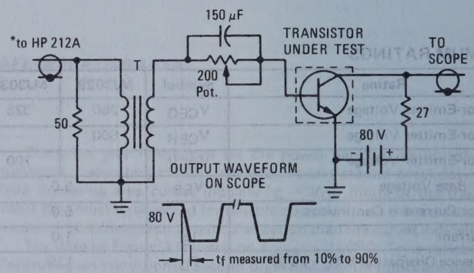
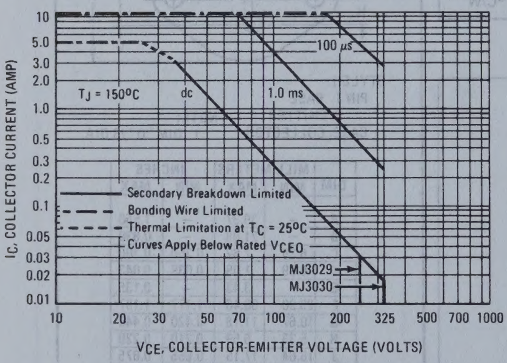


FIGURE 3 — TEST FOR FALL TIME



*HP 212A: Set for 10 µs wide pulses at 2000 pulses per sec. (500 µs intervals). Adjust for I_{B1} = 0.8 A.
Bias: Adjust to 1.5 V on a VTVM across the 200 Ω Pot.
T: Pulse Transformer: Motorola Part No. 25D68782A01.

FIGURE 4 — ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 4 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

MJ3040 (SILICON)
thru
MJ3042

Advance Information

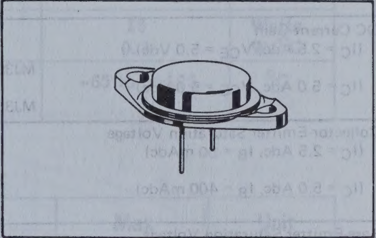
HIGH VOLTAGE SILICON POWER DARLINGTONS

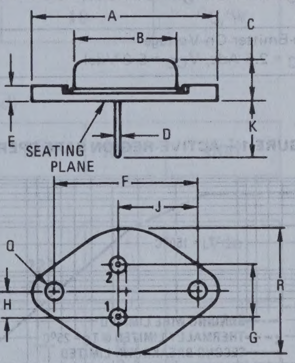
. . . developed for line operated amplifier, series pass and switching regulator applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 300 Vdc (Min) — MJ3040, MJ3041
  = 350 Vdc (Min) — MJ3042
- High DC Current Gain —
  h_{FE} = 100 (Min) @ I_C = 2.5 Adc — MJ3040
  = 250 (Min) @ I_C = 2.5 Adc — MJ3041, MJ3042
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 2.2 Vdc (Max) @ I_C = 2.5 Adc
- Monolithic Construction with Built-In
  Base-Emitter Shunt Resistors

DARLINGTON
7 AMPERE
POWER TRANSISTORS
NPN SILICON

300, 350 VOLTS
100 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

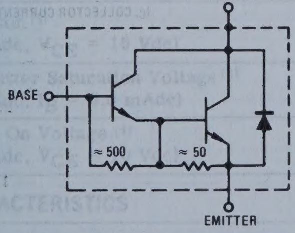
MAXIMUM RATINGS

Rating	Symbol	MJ3040	MJ3041	MJ3042	Unit
Collector-Base Voltage	V_{CB}	400	400	500	Vdc
Collector-Emitter Voltage	V_{CEO}	300	300	350	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous	I_C	← 7.0 →			Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	← 100 → ← 0.8 →			Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	$^oC/W$

DARLINGTON SCHEMATIC



This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	MJ3040, MJ3041 MJ3042	$V_{CEO(sus)}$	300 350	— —	Vdc
Collector Cutoff Current (V_{CB} = 400 Vdc, I_E = 0) (V_{CB} = 500 Vdc, I_E = 0) (V_{CB} = 400 Vdc, I_E = 0, T_C = 100°C) (V_{CB} = 500 Vdc, I_E = 0, T_C = 100°C)	MJ3040, MJ3041 MJ3042 MJ3040, MJ3041 MJ3042	I_{CBO}	— — — —	1.0 1.0 5.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	20	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	MJ3040 MJ3041, MJ3042 MJ3040 MJ3041, MJ3042	h_{FE}	100 250 25 50	— — — —	—
Collector-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 50 mAdc) (I_C = 5.0 Adc, I_B = 400 mAdc)		$V_{CE(sat)}$	— —	2.2 2.5	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 400 mAdc)		$V_{BE(sat)}$	—	3.0	Vdc
Base-Emitter On Voltage (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	2.5	Vdc

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA

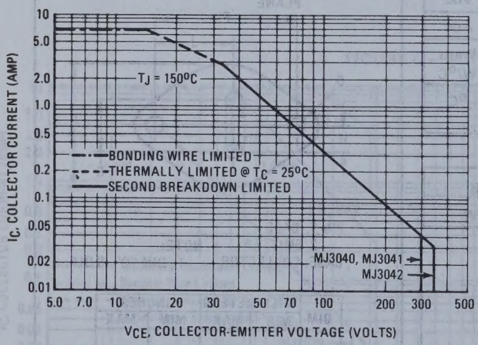
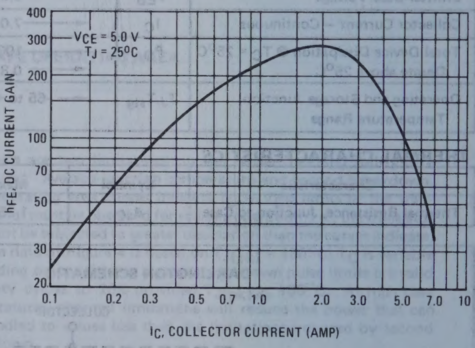


FIGURE 2 — DC CURRENT GAIN



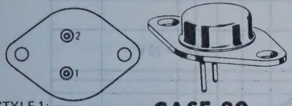
There are two limitations on the power handling ability of a transistor — average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN415).

MJ3101 (SILICON)

For Specifications, See MJ2249 Data.

MJ3201 (SILICON)
MJ3202



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

CASE 80
(TO-66)

High-voltage NPN silicon transistors designed for use in line-operated equipment such as audio output amplifiers; low-current, high-voltage converters; and ac line relays.

MAXIMUM RATINGS

Rating	Symbol	MJ3201	MJ3202	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	225	300	Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current-Continuous	I_C	100		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.1		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to + 175		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	10	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage [1] (I_C = 1.0 mAdc, I_B = 0)	MJ3201 MJ3202	BV_{CEO}	225 300	— —	Vdc
Collector Cutoff Current (V_{CB} = 225 Vdc, I_E = 0) (V_{CB} = 300 Vdc, I_E = 0)	MJ3201 MJ3202	I_{CBO}	— —	0.1 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain [1] (I_C = 50 mAdc, V_{CE} = 10 Vdc)		h_{FE}	30	200	—
Collector-Emitter Saturation Voltage [1] (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage [1] (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	15	—	MHz

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

FIGURE 1 — DC CURRENT GAIN

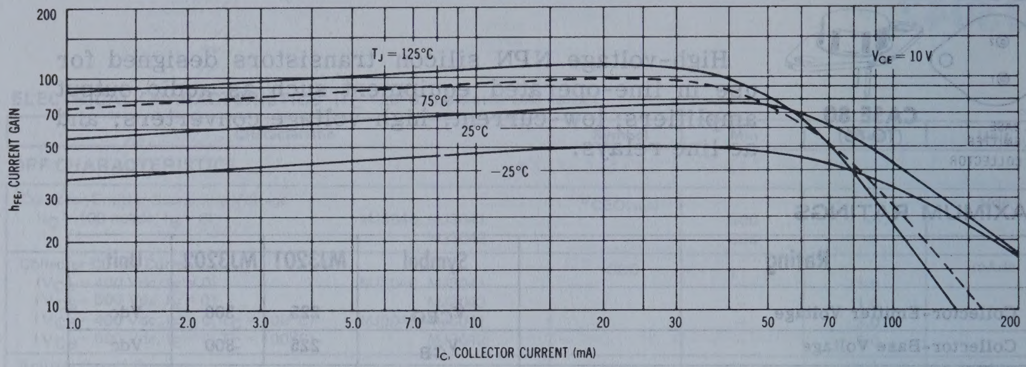


FIGURE 2 — COLLECTOR OUTPUT CHARACTERISTICS

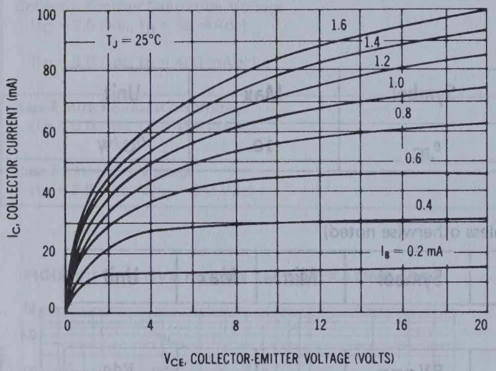


FIGURE 3 — TRANSCONDUCTANCE

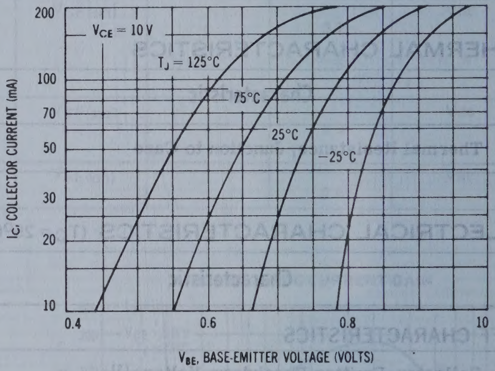
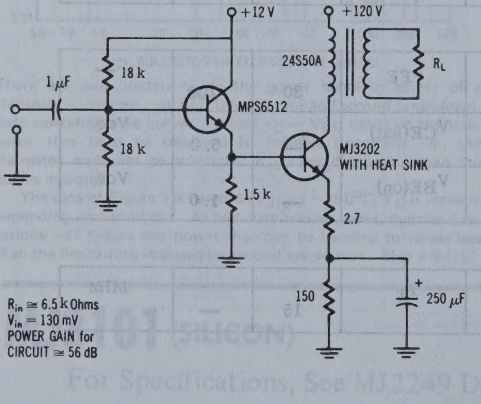
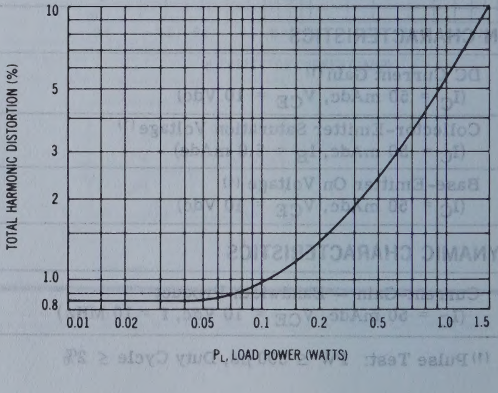


FIGURE 4 — TYPICAL AUDIO AMPLIFIER



+12 V
+120 V
18 k
1 μF
MPS6512
18 k
24S50A
R_L
MJ3202
WITH HEAT SINK
1.5 k
2.7
150
250 μF
$R_{in} \cong 6.5$ k Ohms
$V_{in} = 130$ mV
POWER GAIN for CIRCUIT ≅ 56 dB

FIGURE 5 — AMPLIFIER DISTORTION



MJ3260 (SILICON)

HORIZONTAL DEFLECTION SILICON TRANSISTOR

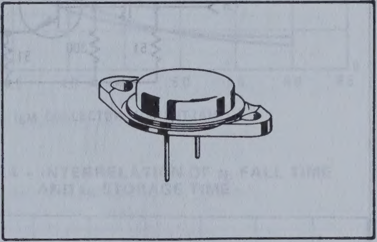
. . . designed for use in large screen, 21″, 23″ and 25″ color television receivers, using 90° deflection circuits.

- Collector-Emitter Voltage — V_{CER} = 700 Vdc
- Collector Current — I_C = 6.0 Adc
- Fall Time @ I_C = 5.5 Adc — t_f = 0.4 μs (Typ) = 1.0 μs (Max)
- Circuit Information Included — Complete Technical Dissertation on Requirements for Optimum Circuit Performance

6 AMPERE

POWER TRANSISTOR
NPN SILICON

700 VOLTS
80 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	700	Vdc
Collector-Base Voltage	V_{CB}	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	6.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	80 0.64	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

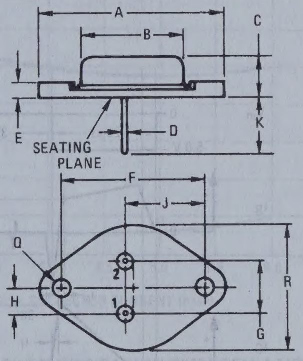
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.56	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	250	—	—	Vdc
Collector Cutoff Current (V_{CE} = 700 Vdc, V_{BE} = 0)	I_{CES}	—	—	1.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 5.5 Adc, I_B = 1.25 Adc)	$V_{CE(sat)}$	—	—	6.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.5 Adc, I_B = 1.25 Adc)	$V_{BE(sat)}$	—	—	1.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (2) (I_C = 0.2 Adc, V_{CE} = 5.0 Vdc, f_{test} = 1.0 MHz)	f_T	—	7.5	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	—	—	180	pF
SWITCHING CHARACTERISTICS (Figure 1 and text)					
Fall Time (I_C = 5.5 Adc, I_{B1} = 1.25 Adc, L_B = 2.0 μH, R_B = 1.6 Ohms)	t_f	—	0.4	1.0	μs

(1) Pulse Test: Pulse Width 300 μs, Duty Cycle ≈ 2.0%..

(2) $f_T = |h_{fe}| \bullet f_{test}$



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

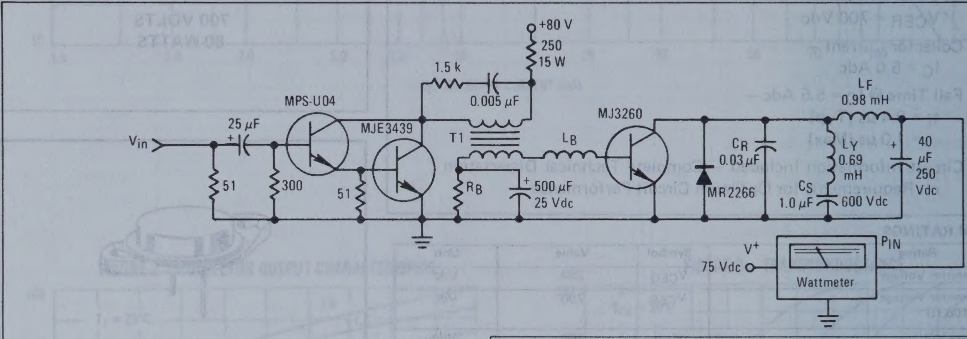
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

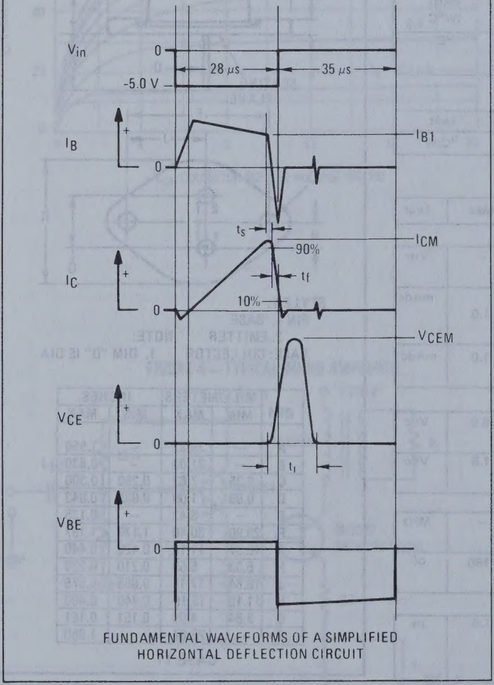
CASE 11

CIRCUIT OPTIMIZATION

Test/application circuit and operating waveforms for MJ3260 are shown in Figure 1. It may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, the circuit was designed with operating efficiency in mind, so that it could be used to evaluate devices by one simple criterion, supply power input. Excessive power input can be caused by a variety of problems, but it is the dissipation itself that is of fundamental importance. Once the transistor operating point has been established, fixed circuit values may be selected for the test fixture. Factory testing may then be made with one meter reading, without adjustment of the test apparatus.

FIGURE 1 – TEST CIRCUIT AND WAVEFORMS





FUNDAMENTAL WAVEFORMS OF A SIMPLIFIED HORIZONTAL DEFLECTION CIRCUIT

DESCRIPTION OF SPECIAL COMPONENTS

DUMMY YOKE INDUCTOR (L_Y)

0.69 mH, 36 turns, #16 AWG enamel wire, 12 turns per layer, 3 layers, 1 mil mylar insulation between layers on 1.3 inch plastic bobbin, enclosed in Ferroxcube cup core No. 4229P3B7, core spacing of 0.006 inch.

DUMMY HIGH VOLTAGE AND HORIZONTAL SCAN TRANSFORMER (L_F)

0.98 mH, 31 turns, #12 AWG enamel wire, 16 turns per layer, 1.9 layers, 1 mil mylar insulation between layers on 2.0 inch plastic bobbin, enclosed in a Ferroxcube cup core K5350-11-3E, core spacing of 0.011 inch.

DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A05-1/4" laminate "E" iron core. Primary Inductance - 39 mH, Secondary Inductance - 0.22 mH, Leakage inductance with primary shorted - 2.0 µH. Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

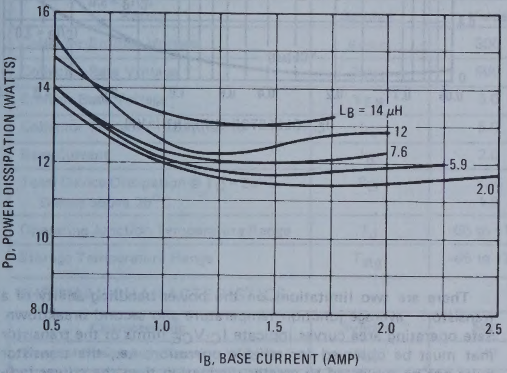
BASIC CONSIDERATIONS

The primary consideration when choosing a deflection transistor for a conventional (parallel connected) circuit, as shown in Figure 1, is one of voltage capability. The flyback voltage to which the device will be subjected is a relatively predictable value with respect to the main power supply voltage. This voltage pulse, (V_{CEM}), shown in Figure 1, will usually be about 8 times the value of V^+, but may be varied somewhat by adjusting retrace time and flyback tuning and can reduce the voltage pulse by 15 to 30% depending on the circuit values chosen.

COLLECTOR CIRCUIT VALUES

The power supply used in the circuit of Figure 1, was chosen to produce a 600 volt collector pulse on the transistor, recommended for regulated applications. The values of yoke (L_Y), flyback primary (L_F), retrace capacitor (C_R), and "S" shaping capacitor (C_S) shown, will result in a peak collector current of about 5.5 A. This is sufficient to deflect (and provide high voltage for) large screen color television receivers using 90° deflection or small and medium-screen color television receivers using 110° deflection. Peak collector currents to 6.0 A may be handled by the MJ3260. Holding the supply constant for most efficient application, adjustment of amount of deflection may be made by raising or lowering L_Y and L_F. Remember that $L_Y I_Y$ is constant for the fixed voltage situation, and actual deflection is proportional to $I_Y \sqrt{L_Y}$. Values of C_S and C_R must be varied inversely with L_Y to maintain retrace and "S" shaping periods.

FIGURE 2 – RELATIONSHIP OF POWER DISSIPATION TO L_B, WITH CHANGING I_{B1}, I_C = 5.5 A PEAK



BASE CIRCUIT VALUES

The driver power supply and driver transistor type can be selected according to convenience. A TO-5 or Uniwatt type will generally be needed. (The Darlington arrangement of the driver transistors used in Figure 1, produces a wide range of I_{B1} current values). Once the driver circuitry is chosen, the turns ratio of the driver transformer can be picked to produce about 4 to 5 volts peak to peak at the base of the output device. Tight coupling between windings is recommended on early designs to allow optimizing leakage inductance by adding inductance externally. Later, the leakage can be "designed in" to the transformer. The R_B and its bypass electrolytic, often called the "speed up" circuit, allows adjustment of I_{B1} (or I_B "end of scan" or I_B end) while still providing a low ac impedance for good turn-off of the output device. In Figure 2, the effects of varying L_B and I_{B1} on the total power input to the deflection circuit are shown. Note that an optimum L_B can be found which will produce low dissipation over a wide range of I_{B1}. This is desirable in order to produce efficient operation over a wide range of circuit component tolerances. Likewise, best L_B also gives the least sensitivity to output transistor h_{FE}.

The best value of L_B found in Figure 2 is 2.0 μH, which is the leakage inductance value of the driver transformer, and no external L is necessary. A lower L_B would have reduced the power dissipation, over a narrow range of I_{B1}. However, a leakage inductance of 2.0 μH is a minimum practical value. The best value of I_{B1} is 2.0 A achieved in the typical device by using R_B = 1.6 Ω, derived experimentally.

These are the choices recommended for the test fixture, when the transistor is used at I_{CM} = 5.5 A. For other values of I_{CM} the drive circuit components must be changed. Figure 3 shows the values of L_B and I_{B1} which should be used. The value of R_B which will be required to produce the corresponding I_{B1} is also given, but of course, it is not an independent variable.

PERFORMANCE

Shown in Figures 4 and 5 are the results which will be typically obtained with the test circuit at various operating conditions.

FIGURE 3 – INTERRELATION OF R_B, L_B, AND I_{B1}

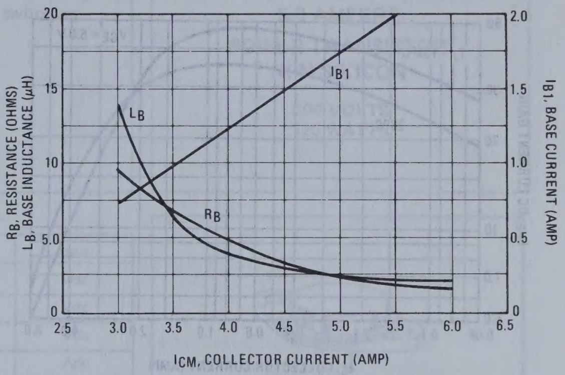


FIGURE 4 – INTERRELATION OF t_f, FALL TIME AND t_s, STORAGE TIME

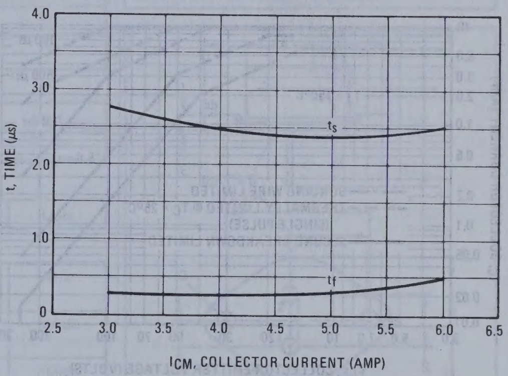
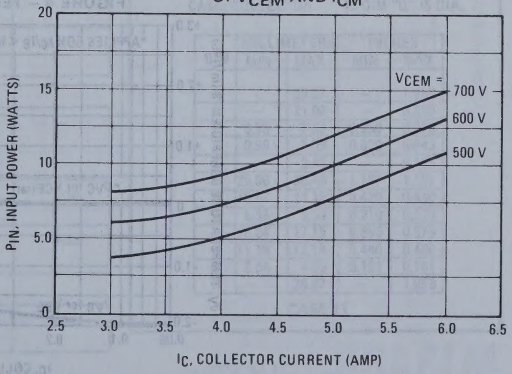


FIGURE 5 – P_{IN}, POWER DISSIPATION WITH DEVIATIONS OF V_{CEM} AND I_{CM}



TYPICAL TRANSISTOR CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

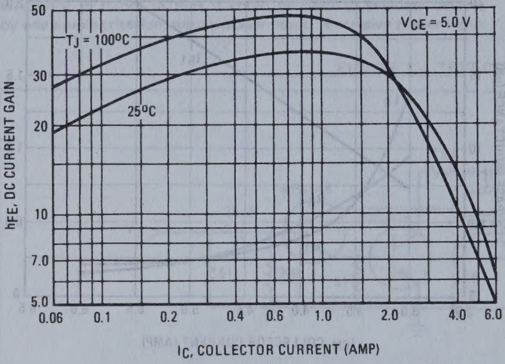


FIGURE 2 – "ON" VOLTAGE

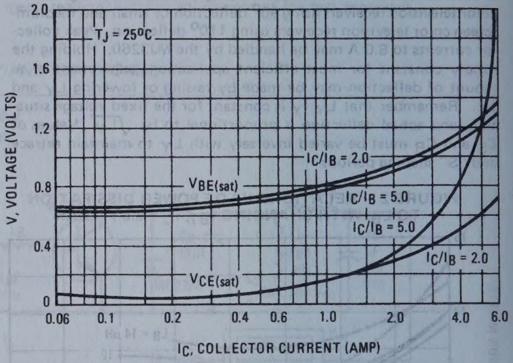
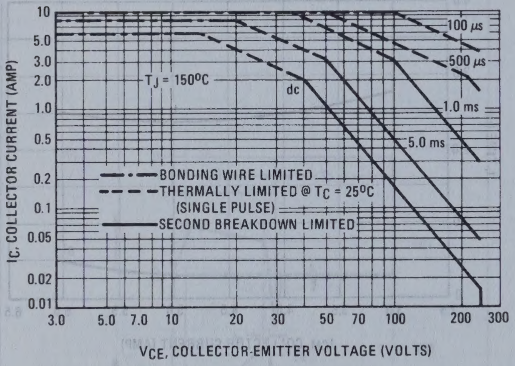


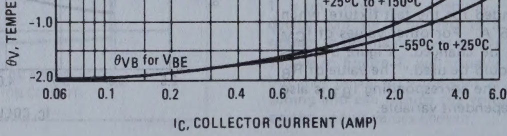
FIGURE 3 – SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 4 – TEMPERATURE COEFFICIENTS



MJ3430 (SILICON)

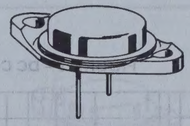
HIGH VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in high-voltage inverters, converters, switching regulators and line operated amplifiers.

- High Collector-Emitter Voltage — V_{CEX} = 400 Vdc
- Excellent DC Current Gain — h_{FE} = 10 (Min) @ I_C = 3.5 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.9 Vdc (Max) @ I_C = 2.5 Adc

5.0 AMPERE
POWER TRANSISTOR
NPN SILICON

300 VOLTS
125 WATTS

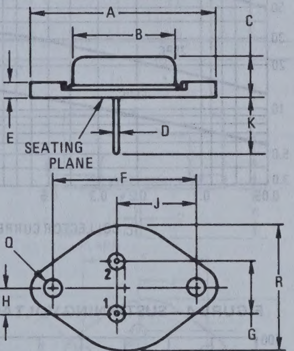


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	400	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	5.0	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

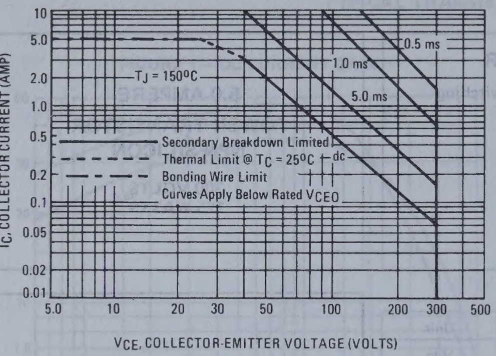
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	300	—	Vdc
Collector Cutoff Current (V_{CE} = 300 Vdc, I_B = 0)	I_{CEO}	—	2.5	mAdc
Collector Cutoff Current	I_{CEX}			mAdc
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc)		—	1.0	
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)		—	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)		15	45	
(I_C = 3.5 Adc, V_{CE} = 5.0 Vdc)		10	—	
Collector-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 0.5 Adc)	$V_{CE(sat)}$	—	0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 0.5 Adc)	$V_{BE(sat)}$	—	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 0.2 Adc, V_{CE} = 10 Vdc)	f_T	2.5	—	MHz

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)}$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – DC CURRENT GAIN

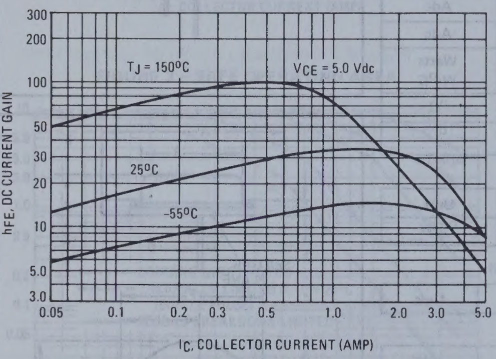


FIGURE 3 – "ON" VOLTAGES

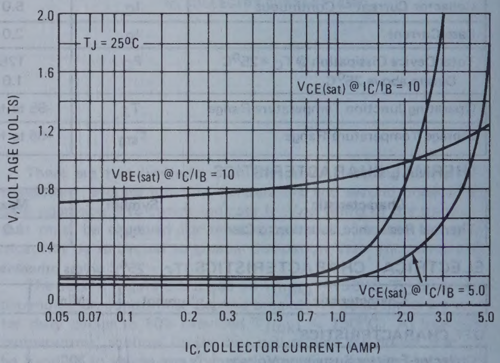


FIGURE 4 – SUSTAINING VOLTAGE TEST LOAD LINE

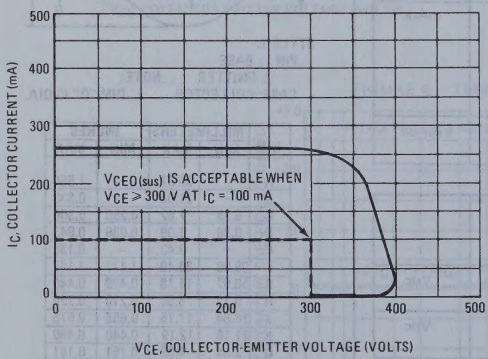
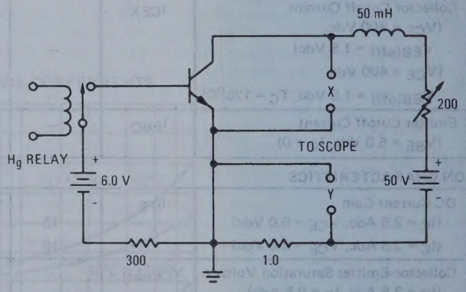


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJ3480 (SILICON)

For Specifications, See BU108 Data.

MJ3583 thru MJ3585 (SILICON)

For Specifications, See 2N3583 Data.

MJ3701 (SILICON)

For Specifications, See MJ2253 Data.

MJ3760 (SILICON)
MJ3761

HORIZONTAL DEFLECTION SILICON TRANSISTORS

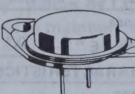
. . . designed for use in large screen color television receivers.

- Collector-Emitter Voltage —
  V_{CER} = 750 Vdc
- Collector Current —
  I_C = 6.0/8.0 Adc
- Fall Time @ I_C = 8.0 Adc —
  $t_f = 0.5\ \mu s$ (Typ) • $t_f = 0.9\ \mu s$ (Max)

6.0/8.0 AMPERE

TRIPLE DIFFUSED POWER TRANSISTORS NPN SILICON

750 VOLTS
80 WATTS



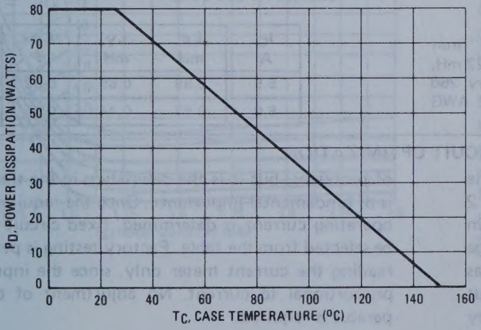
MAXIMUM RATINGS

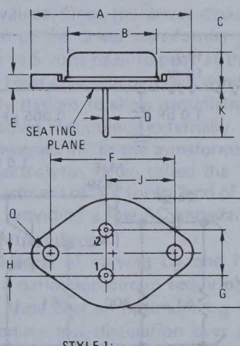
Rating	Symbol	MJ3760	MJ3761	Unit
Collector-Emitter Voltage	V_{CEO}	550		Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	750		Vdc
Collector-Base Voltage	V_{CB}	750		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous — Peak	I_C	6.0 12.0	8.0 16.0	Adc
Base Current	I_B	4.0		Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	80 0.638		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.56	°C/W

FIGURE 1 — POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

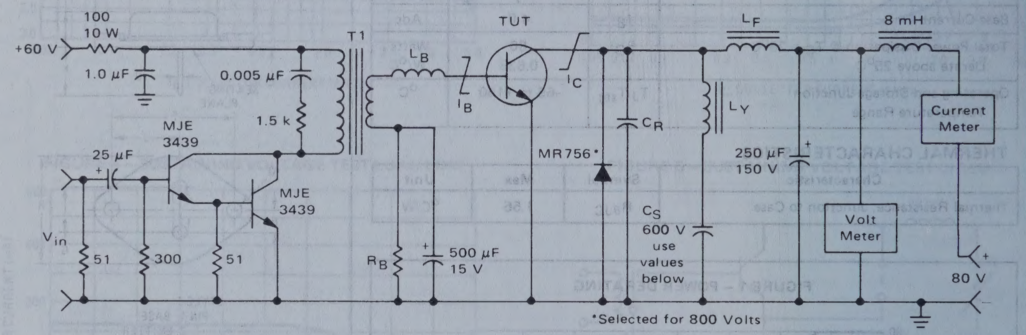
CASE 11

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	550	—	—	Vdc
Collector Cutoff Current (V_{CE} = 750 Vdc, V_{BE} = 0)	I_{CES}	—	—	1.0	mAdc
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 6.0 Adc, I_B = 2.5 Adc) MJ3760 (I_C = 8.0 Adc, I_B = 3.0 Adc) MJ3761	$V_{CE(sat)}$	 — —	 — —	 5.0 5.0	Vdc
Base-Emitter Saturation Voltage (I_C = 6.0 Adc, I_B = 2.5 Adc) MJ3760 (I_C = 8.0 Adc, I_B = 3.0 Adc) MJ3761	$V_{BE(sat)}$	 — —	 — —	 1.5 1.5	Vdc
Second Breakdown Collector Current with Base Forward Biased (t = 1.0 s, V_{CE} = 100 Vdc)	$I_{S/b}$	200	—	—	mAdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1), (2) (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc, f_{test} = 1.0 MHz)	f_T	—	7.5	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	—	150	—	pF
SWITCHING CHARACTERISTICS					
Fall Time: MJ3760 (I_C = 5.5 Adc, I_{B1} = 1.5 Adc, L_B = 20 µH, See Figure 2)	t_f	—	0.33	0.7	µs
Fall Time: MJ3761 (I_C = 8.0 Adc, I_{B1} = 2.0 Adc, L_B = 20 µH, See Figure 2)	t_f	—	0.5	0.9	µs

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – TEST CIRCUIT



*Selected for 800 Volts

DRIVER TRANSFORMER (T1)

Motorola part number 25D68782A05-1/4" laminate "E" iron core. Primary Inductance—39 mH, Secondary Inductance—0.22 mH, Leakage inductance with primary shorted—2.0 µH. Primary 260 turns, #28 AWG enamel wire, Secondary 17 turns, #22 AWG enamel wire.

I_C A	L_F mH	L_Y mH	C_R µF	C_S µF
5.5	0.98	0.65	0.03	1.0
8.0	0.57	0.44	0.05	6.0

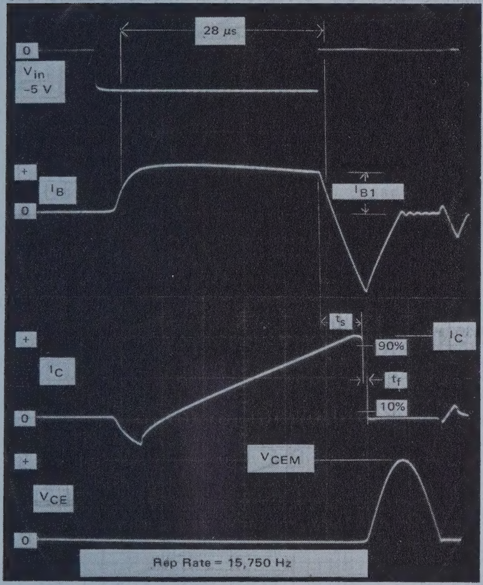
TEST CIRCUIT OPTIMIZATION

The test circuit and operating waveforms for the MJ3760 and MJ3761 transistors are shown in Figures 2 and 3. The test circuit may be used to evaluate devices in the conventional manner, i.e., to measure fall time, storage time, and saturation voltage. However, this circuit was designed to evaluate devices by a simple criterion, input power. Excessive power input can be caused by a variety of problems, but it is the dissipation in the transistor that is of fundamental importance. Once the required transistor operating current is determined, fixed circuit values may be selected from the table. Factory testing is performed by reading the current meter only, since the input power is proportional to current. No adjustment of the test apparatus is required.

BASIC CONSIDERATIONS

The primary consideration when choosing a deflection transistor for a conventional (parallel connected) circuit, as shown in Figure 2, is voltage capability. The flyback voltage that the device will be subjected to is a relatively predictable value with respect to the main power supply voltage. This voltage pulse, shown in Figure 3, will usually be 8 times the 80-volt power supply voltage or approximately 640 volts, but may be varied slightly by adjusting retrace time and flyback tuning. For this reason, high voltage devices are particularly useful in cost conscious solid-state receivers as they permit the use of an off-the-line half wave power supply.

FIGURE 3 – TEST CIRCUIT WAVEFORMS



Fundamental waveforms of a simplified horizontal deflection circuit.

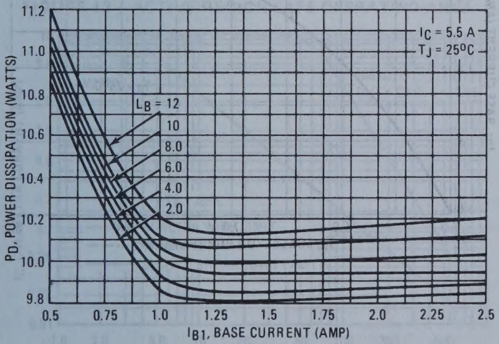
The power supply used in the circuit of Figure 2, was chosen to produce approximately a 650 V collector pulse on the transistor, a conservative value, recommended for unregulated applications.

The values of yoke inductance (L_Y), flyback primary inductance (L_F), retrace capacitor (C_R) and "S" shaping capacitor (C_S) are shown for operating collector currents of 5.5 A which is suitable for 90° color and 110° large screen black and white receivers, and 8.0 A for 110° color receivers. Peak collector currents to 10 A may be handled by these transistors. The most efficient application results when the power supply voltage is held constant. Adjustments of the amount of deflection can then be made by raising or lowering L_Y and L_F. $L_Y I_Y$ is constant for the fixed voltage situation, and actual deflection is proportional to $I_Y \sqrt{L_Y}$. Values of C_S and C_R must be varied inversely with L_Y to maintain retrace and "S" shaping periods.

TEST CIRCUIT VALUES

The driver power supply and driver transistor type can be selected according to convenience. A TO-5 or plastic power type will generally be needed. For testing convenience, the Darlington arrangement of the driver transistor shown in Figure 2 was used to produce a wide range of I_{B1} current values. Once the driver circuitry is chosen, the turns ratio of the driver transformer can be selected to produce 4 to 5 volts peak-to-peak at the base of the output device. Tight coupling between windings is recommended on early designs to allow optimizing leakage inductance by adding inductance externally. Later, the leakage can be "designed in" to the transformer. The R_B and its bypass electrolytic, often called the "speed up" circuit, allows adjustment of I_{B1} (or I_B "end of scan" or I_B end) while still providing a low AC impedance for good turn-off of the output device.

FIGURE 4 – RELATIONSHIP OF POWER DISSIPATION TO L_B WITH CHANGING I_{B1}, I_C = 5.5 A



In Figure 4, the effects of varying L_B and I_{B1} on total power input to a deflection circuit requiring an I_C of 5.5 A are shown. Note that an optimum L_B can be found which will produce low dissipation over a wide range of I_{B1}. This is desirable in order to produce efficient operation over a wide range of circuit component tolerances. Likewise, best L_B also gives the least sensitivity to output transistor h_{FE}.

The best value of L_B found in Figure 4 is 2.0 μH. This is the sum of the actual leakage inductance of the driver transformer (secondary inductance with primary shorted) and an external L if necessary. The value of I_{B1} is approximately 2.5 A achieved in a typical device by using R_B = 0.7 Ω, which was derived experimentally. These are the choices recommended for the test fixture when the transistor is used at I_C = 5.5 A.

With the increasing usage of the toroidal yoke and the inherently lower inductance, a much higher collector current will be demanded from the horizontal output transistor. Figure 5 shows the relationship of power dissipation to L_B with changing I_{B1} when an I_C of 8.0 amps is required.

The best value of L_B, found in Figures 5 and 7, is 2.0 µH. The best value of I_{B1}, found in Figure 8, is 2.5 amps. In Figure 5, the 2.5 amp base current falls in the flatter region of the 2.0 µH base inductance curve. The optimum base resistance R_B in Figure 6 is 0.7 ohms to produce the I_{B1} value of 2.5 amps.

A lower value of L_B would have reduced the power dissipation by a small value. However, a leakage inductance of 2.0 µH is a minimum practical value for driver transformer manufacturers to meet as the secondary winding leakage inductance.

For other values of I_C, the drive circuit components must be changed. Figures 7 and 8 show the values of L_B and I_{B1} which should be used. The value of R_B, which will be required to produce the corresponding I_{B1} value, is also given; however, it is not an independent variable.

Figures 9 and 10 show the typical results that will be obtained with the test circuit of Figure 2 at various operating conditions.

INTERRELATION OF BASE RESISTANCE, BASE INDUCTANCE AND BASE CURRENT

FIGURE 5 – RELATIONSHIP OF POWER DISSIPATION TO L_B WITH CHANGING I_{B1}

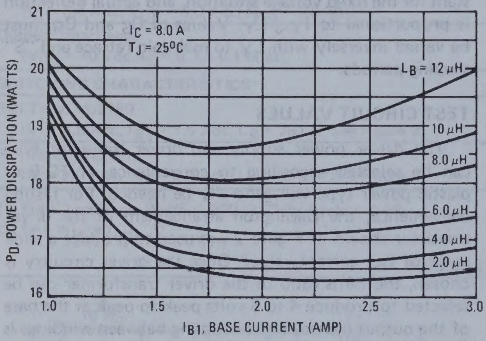


FIGURE 6 – OPTIMUM BASE RESISTANCE

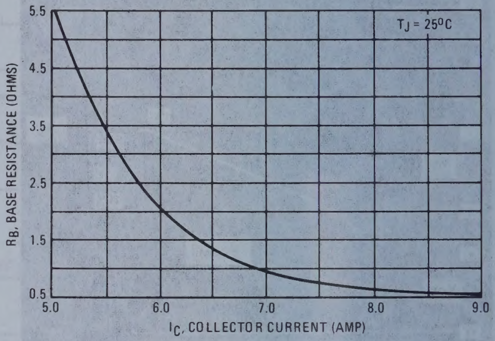


FIGURE 7 – OPTIMUM BASE INDUCTANCE

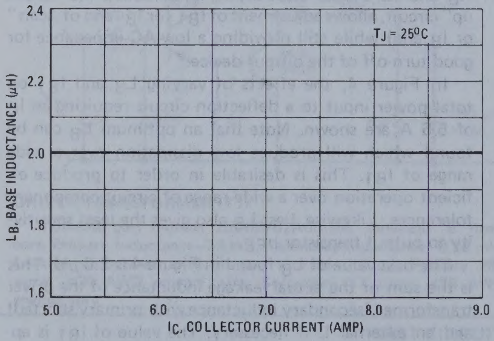


FIGURE 8 – OPTIMUM BASE CURRENT

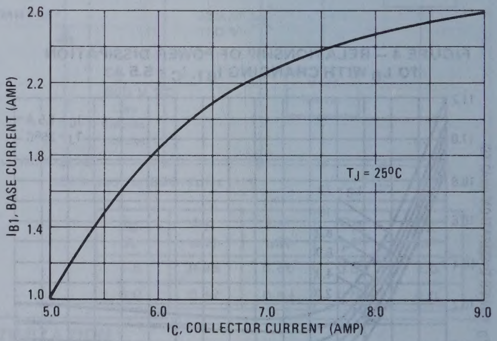


FIGURE 9 – INTERRELATION OF t_f, FALL TIME AND t_s, STORAGE TIME

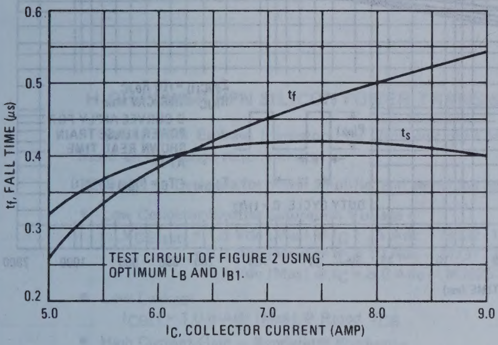


FIGURE 10 – EFFECT OF COLLECTOR CURRENT ON INPUT POWER

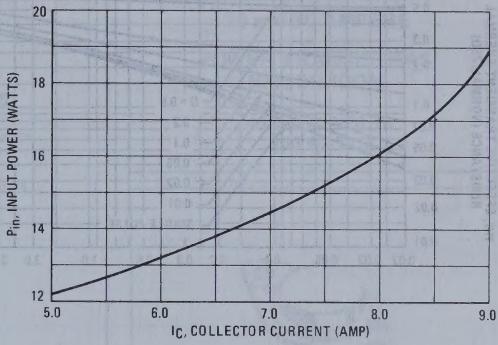


FIGURE 11 – DC CURRENT GAIN

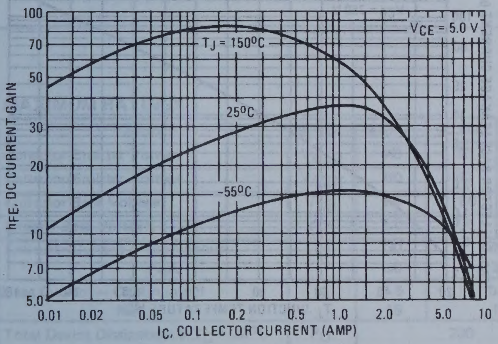


FIGURE 12 – "ON" VOLTAGES

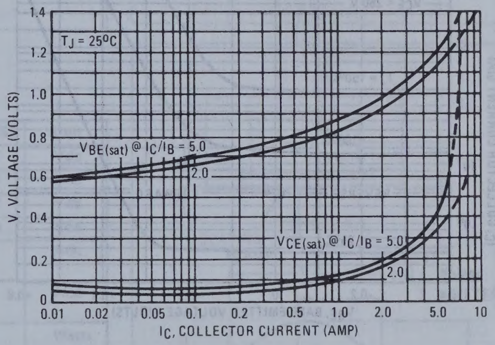
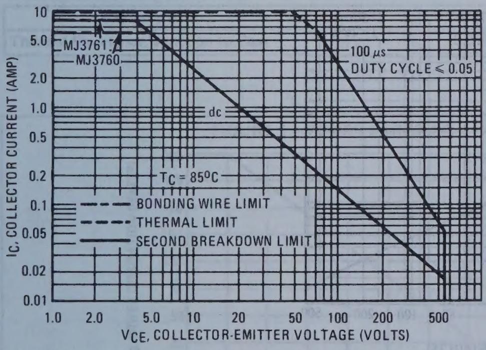


FIGURE 13 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on T_C = 85°C. The thermal pulse limit shown is valid for a duty cycle of 5.0%. For other conditions, $T_{J(pk)}$ must be calculated and kept below 150°C. $T_{J(pk)}$ may be calculated from the data of Figure 14. At higher case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitation imposed by second breakdown.

FIGURE 14 — THERMAL RESPONSE

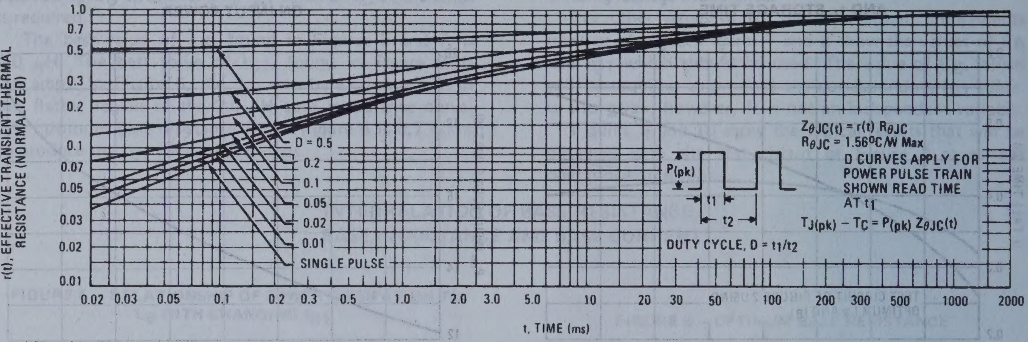


FIGURE 15 — COLLECTOR CUT-OFF REGION

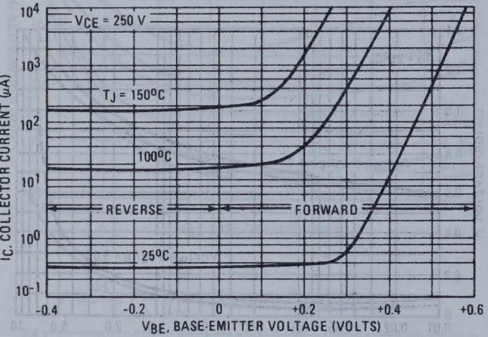


FIGURE 16 — COLLECTOR-BASE LEAKAGE CURRENT

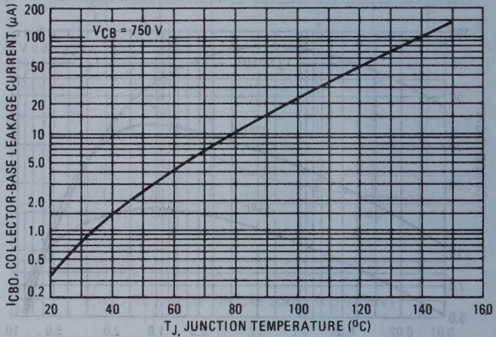
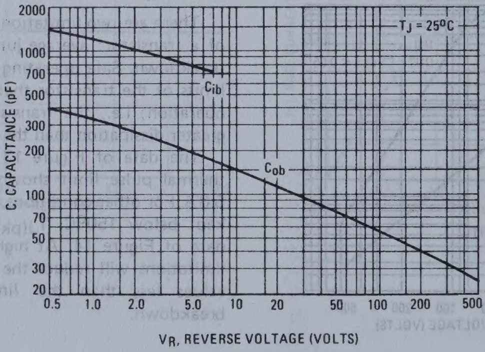


FIGURE 17 — CAPACITANCE



MJ3771, MJ3772, MJ6257 (SILICON)

HIGH POWER NPN SILICON POWER TRANSISTORS

Select from Epibase transistors for ultimate circuit performance based on the design requirements.

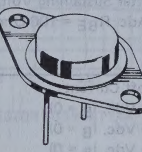
EPIBASE — Designed for power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 15 Adc — MJ3771
  = 0.8 Vdc (Max) @ I_C = 10 Adc — MJ3772
  = 0.7 Vdc (Max) @ I_C = 8.0 Adc — MJ6257
- Low Leakage —
  I_{CBO} = 1.0 mAdc (Max) @ Rated V_{CB}
- High Current-Gain — Bandwidth Product —
  f_T = 2.0 MHz (Min) @ I_C = 1.0 Adc

20 and 30 AMPERE

POWER TRANSISTORS
NPN SILICON

40 and 60 VOLTS
200 WATTS



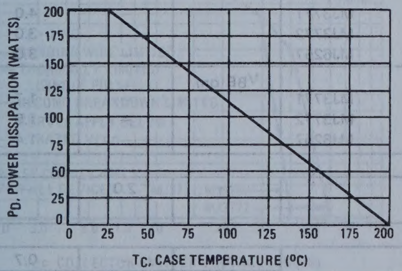
MAXIMUM RATINGS

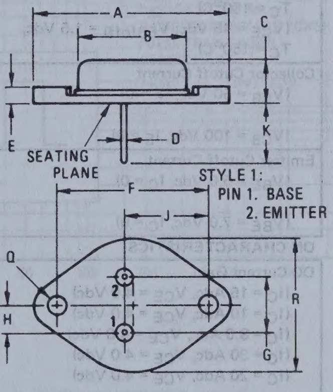
Rating	Symbol	MJ3771	MJ3772	MJ6257	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	40	Vdc
Collector-Emitter Voltage	V_{CEX}	50	80	50	Vdc
Collector-Base Voltage	V_{CB}	50	100	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	7.0	5.0	Vdc
Collector Current — Continuous	I_C	30	20		Adc
Peak		30	30		
Base Current — Continuous	I_B	7.5	5.0		Adc
Peak		15	15		
Total Device Dissipation @ T_C = 25°C	P_D	200			Watts
Derate above 25°C		1.14			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.875	°C/W

FIGURE 1 — POWER DERATING





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

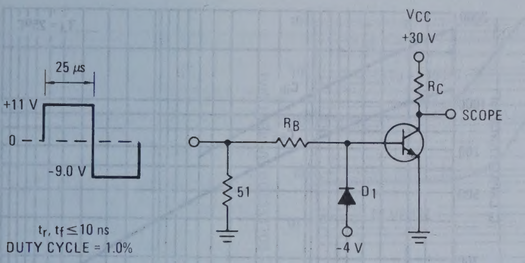
Collector connected to case.

CASE 11

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	MJ3771	$V_{CEO(sus)}$	40	–	Vdc
	MJ3772		60	–	
	MJ6257		40	–	
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, $V_{EB(off)}$ = 1.5 Vdc, R_{BE} = 100 Ohms	MJ3771	$V_{CEX(sus)}$	50	–	Vdc
	MJ3772		80	–	
	MJ6257		50	–	
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, R_{BE} = 100 Ohms)	MJ3771	$V_{CER(sus)}$	45	–	Vdc
	MJ3772		70	–	
	MJ6257		45	–	
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	MJ3771	I_{CEO}	–	2.0	mAdc
(V_{CE} = 50 Vdc, I_B = 0)	MJ3772		–	2.0	
(V_{CE} = 25 Vdc, I_B = 0)	MJ6257		–	2.0	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ3771	I_{CEX}	–	1.0	mAdc
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ3772		–	1.0	
(V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ6257		–	1.0	
(V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ3771		–	2.0	
	MJ3772		–	2.0	
(V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ6257		–	5.0	
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	MJ3771	I_{CBO}	–	1.0	mAdc
	MJ6257		–	1.0	
(V_{CB} = 100 Vdc, I_E = 0)	MJ3772		–	1.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	MJ3771	I_{EBO}	–	1.0	mAdc
	MJ6257		–	1.0	
(V_{BE} = 7.0 Vdc, I_C = 0)	MJ3772		–	1.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 15 Adc, V_{CE} = 4.0 Vdc)	MJ3771	h_{FE}	15	60	–
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	MJ3772		15	60	
(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	MJ6257		15	75	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	MJ3771		5.0	–	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	MJ3772		5.0	–	
	MJ6257		5.0	–	
Collector-Emitter Saturation Voltage (I_C = 15 Adc, I_B = 1.5 Adc)	MJ3771	$V_{CE(sat)}$	–	1.0	Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	MJ3772		–	0.8	
(I_C = 8.0 Adc, I_B = 0.8 Adc)	MJ6257		–	0.7	
(I_C = 30 Adc, I_B = 6.0 Adc)	MJ3771		–	4.0	
(I_C = 20 Adc, I_B = 4.0 Adc)	MJ3772		–	3.0	
	MJ6257		–	3.0	
Base-Emitter On Voltage (I_C = 15 Adc, V_{CE} = 4.0 Vdc)	MJ3771	$V_{BE(on)}$	–	1.7	Vdc
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	MJ3772		–	1.5	
(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	MJ6257		–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 1.0 MHz)		f_T	2.0	–	MHz
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 30 Vdc, I_C = 10 Adc I_{B1} = I_{B2} = 1.0 Adc)	t_r	–	0.7	μs
Storage Time		t_s	–	1.0	μs
Fall Time		t_f	–	0.8	μs

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B AND R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

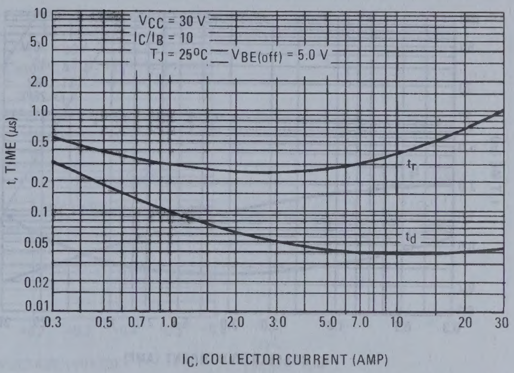


FIGURE 4 – THERMAL RESPONSE

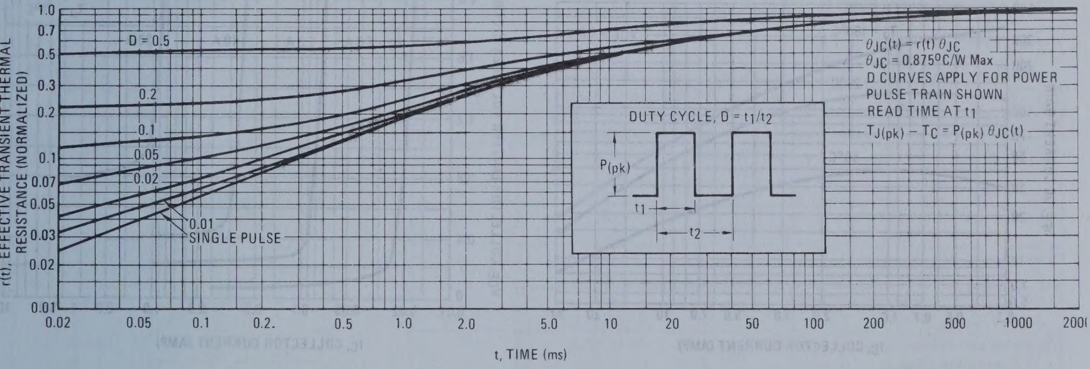
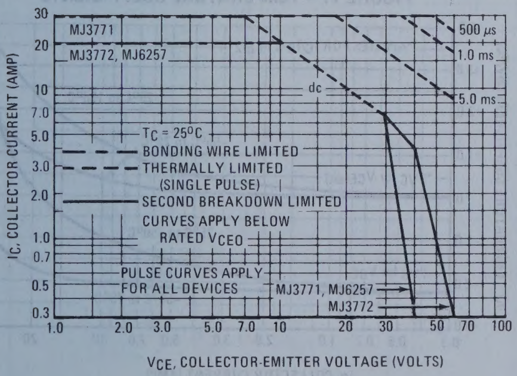


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^\circ C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See Motorola Application Note AN-415)

FIGURE 6 – TURN-OFF TIME

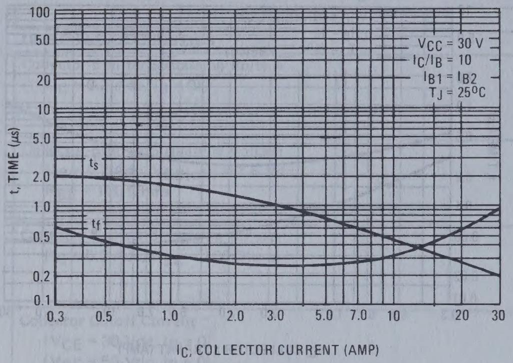


FIGURE 7 – CAPACITANCE

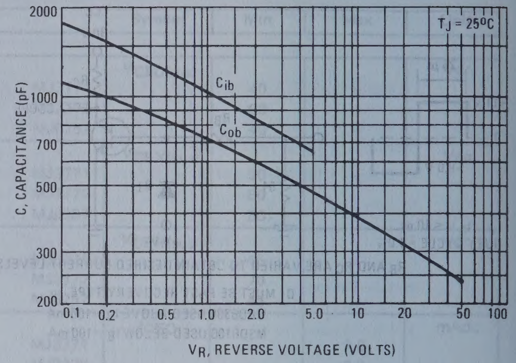


FIGURE 8 – DC CURRENT GAIN

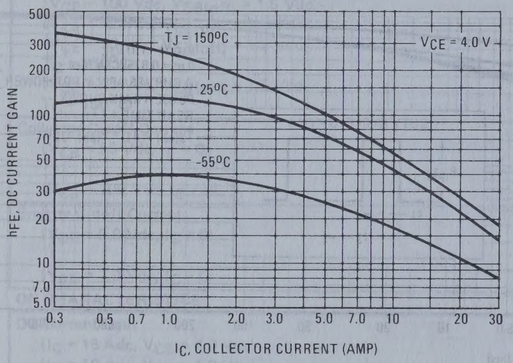


FIGURE 9 – COLLECTOR SATURATION REGION

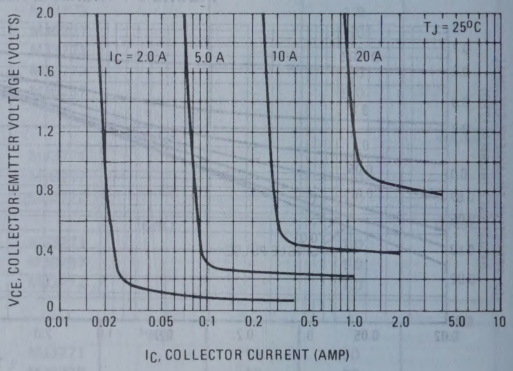


FIGURE 10 – "ON" VOLTAGES

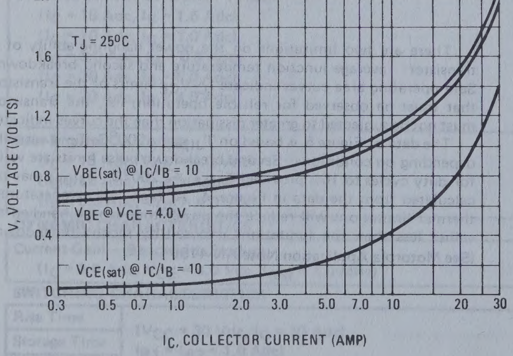


FIGURE 11 – TEMPERATURE COEFFICIENTS

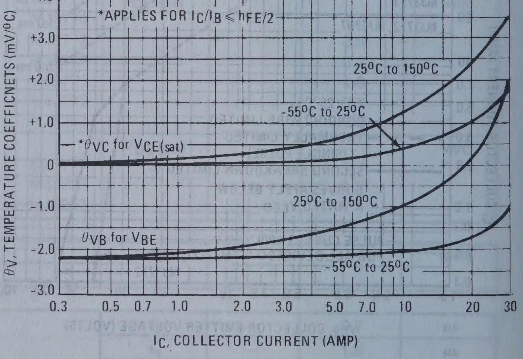
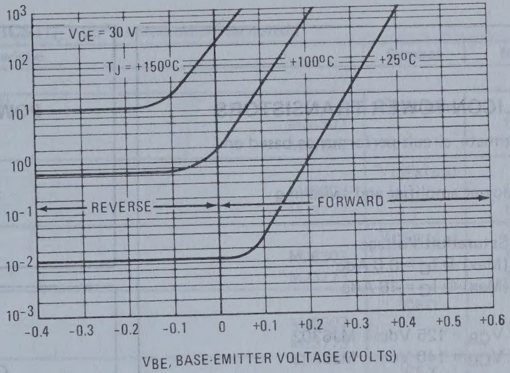


FIGURE 12 – COLLECTOR CUTOFF REGION



MJ3773, MJ6302 (SILICON)

HIGH POWER NPN SILICON POWER TRANSISTORS

Epibase transistors for ultimate circuit performance based on the designer's requirement.

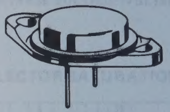
EPIBASE — designed for power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.8 Vdc (Max) @ I_C = 8.0 Adc
  = 2.0 Vdc (Max) @ I_C = 16 Adc
- Low Leakage —
  I_{CBO} = 1.0 mAdc @ V_{CB} = 125 Vdc — MJ6302
  = 1.0 mAdc @ V_{CB} = 140 Vdc — MJ3773
- High Current-Gain — Bandwidth Product —
  f_T = 1.0 MHz (Min) @ I_C = 1.0 Adc

16 AMPERE
POWER TRANSISTORS

NPN SILICON

120, 140 VOLTS
200 WATTS



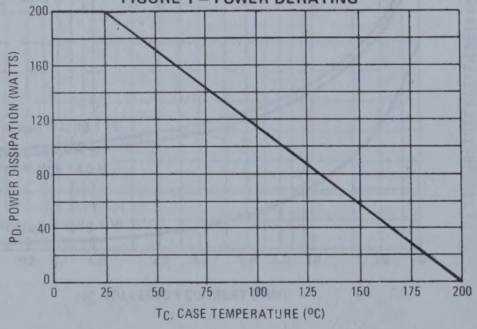
MAXIMUM RATINGS

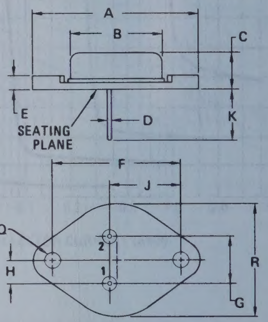
Rating	Symbol	MJ6302	MJ3773	Unit
Collector-Emitter Voltage	V_{CEO}	120	140	Vdc
Collector-Emitter Voltage	V_{CEX}	140	160	Vdc
Collector-Base Voltage	V_{CB}	140	160	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous Peak	I_C	16 30		Adc
Base Current — Continuous Peak	I_B	4.0 15		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJ3773 MJ6302	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.875	°C/W

FIGURE 1 — POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

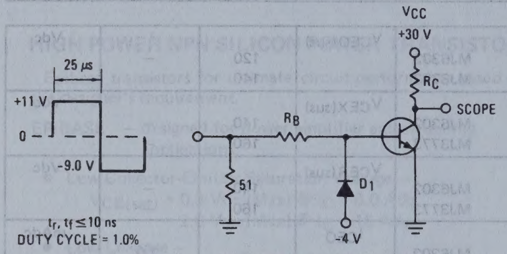
CASE 11-03

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 0.2 Adc, I_B = 0)	MJ6302		120	–	
	MJ3773		140	–	
Collector-Emitter Sustaining Voltage		$V_{CEX(sus)}$			Vdc
(I_C = 0.2 Adc, $V_{BE(off)}$ = 1.5 Vdc,	MJ6302		140	–	
R_{BE} = 100 Ohms)	MJ3773		160	–	
Collector-Emtiter Sustaining Voltage		$V_{CER(sus)}$			Vdc
(I_C = 0.2 Adc, R_{BE} = 100 Ohms)	MJ6302		140	–	
	MJ3773		160	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 100 Vdc, I_B = 0)	MJ6302		–	2.0	
(V_{CE} = 120 Vdc, I_B = 0)	MJ3773		–	2.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ6302		–	1.0	
(V_{CE} = 140 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ3773		–	1.0	
(V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ6302		–	5.0	
(V_{CE} = 140 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ3773		–	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 125 Vdc, I_E = 0)	MJ6302		–	1.0	
(V_{CB} = 140 Vdc, I_E = 0)	MJ3773		–	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)	MJ6302		–	1.0	
	MJ3773		–	1.0	
ON CHARACTERISTICS(1)					
DC Current Gain		h_{FE}			–
(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	MJ6302		15	60	
	MJ3773		15	60	
(I_C = 16 Adc, V_{CE} = 4.0 Vdc)	MJ6302		5.0	–	
	MJ3773		5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 8.0 Adc, I_B = 800 mAdc)	MJ6302		–	0.8	
	MJ3773		–	0.8	
(I_C = 16 Adc, I_B = 3.2 Adc)	MJ6302		–	2.0	
	MJ3773		–	2.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 8.0 Adc, V_{CE} = 4.0 Vdc)	MJ6302		–	1.5	
	MJ3773		–	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f_{test} = 0.5 MHz)			1.0	–	
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)			40	–	
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 30 Vdc, I_C = 8.0 Adc, $I_{B1} = I_{B2}$ = 0.8 Adc)	t_r	–	1.5	μs
Storage Time		t_s	–	2.0	μs
Fall Time		t_f	–	1.8	μs

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FIGURE 3 – TURN-ON TIME

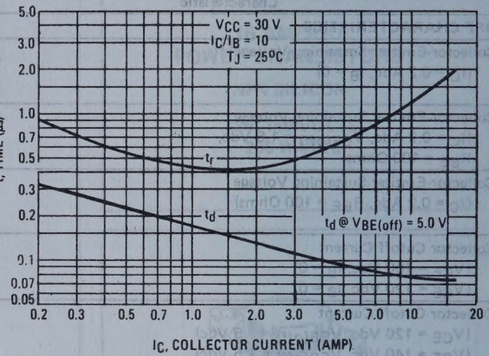


FIGURE 4 – THERMAL RESPONSE

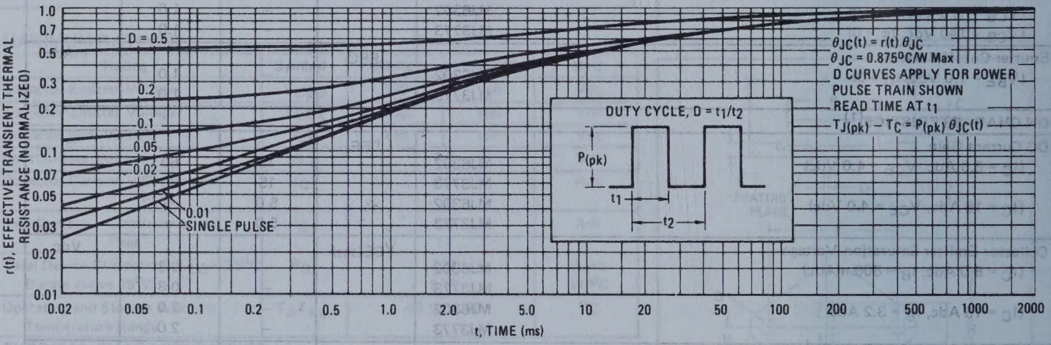
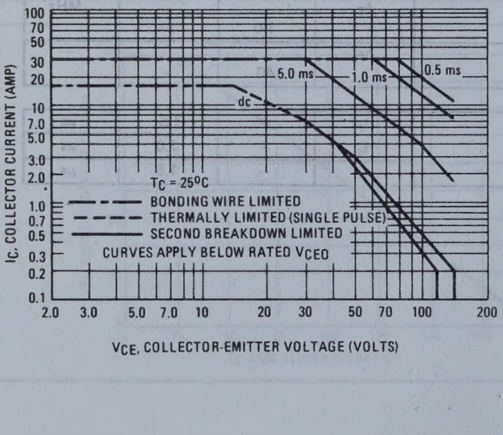


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

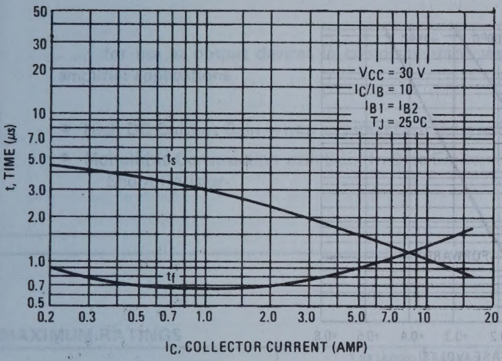


FIGURE 7 – CAPACITANCE

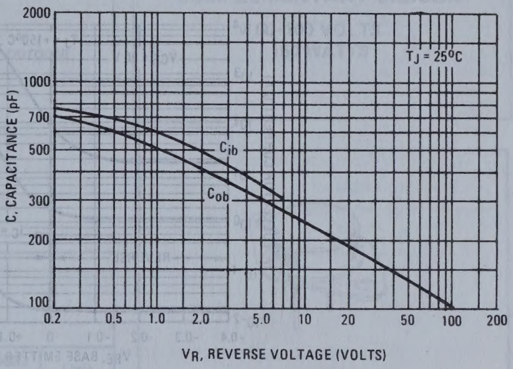


FIGURE 8 – DC CURRENT GAIN

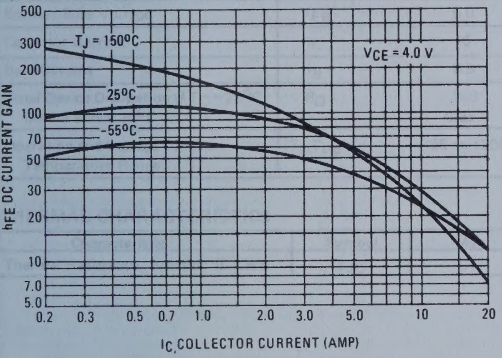


FIGURE 9 – COLLECTOR SATURATION REGION

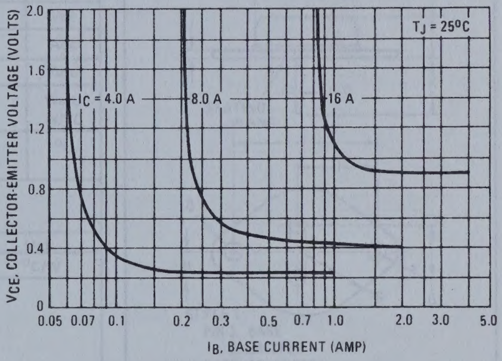


FIGURE 10 – "ON" VOLTAGES

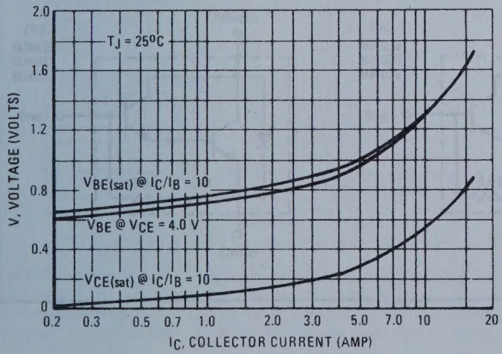


FIGURE 11 – TEMPERATURE COEFFICIENTS

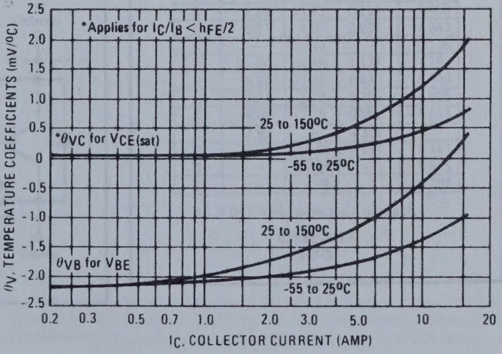
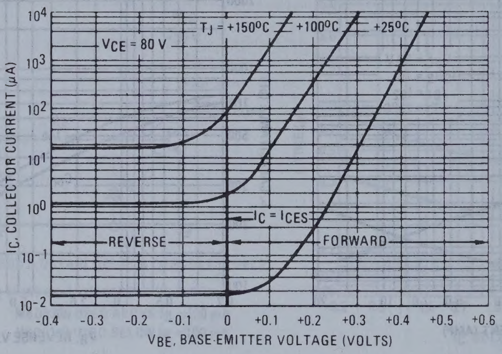


FIGURE 12 – COLLECTOR CUTOFF REGION



MJ4030, MJ4031, MJ4032 PNP (SILICON)
MJ4033, MJ4034, MJ4035 NPN

MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain – h_{FE} = 3500 (Typ) @ I_C = 10 Adc
- Monolithic Construction with Built-In Base-Emitter Shunt Resistor

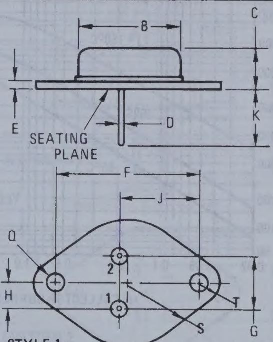
16 AMPERE
DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON
60-100 VOLTS
150 WATTS

MAXIMUM RATINGS

Rating	Symbol	MJ4030 MJ4033	MJ4031 MJ4034	MJ4032 MJ4035	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current	I_C	16			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.857			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W


B
C
E
SEATING PLANE
D
K
F
J
Q
2
1
H
T
S
G

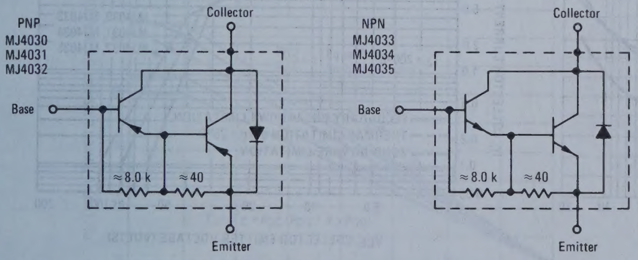
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	–	0.312	–
Q	3.84	4.09	0.151	0.161
S	–	13.34	–	0.525
T	–	4.78	–	0.188

All JEDEC dimensions and notes apply

CASE 1-03
(TO-3)

FIGURE 1 – DARLINGTON CIRCUIT SCHEMATIC


PNP
MJ4030
MJ4031
MJ4032
Collector
Base
≈8.0 k
≈40
Emitter
NPN
MJ4033
MJ4034
MJ4035
Collector
Base
≈8.0 k
≈40
Emitter

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1)	BV_{CEO}			Vdc
(I_C = 100 mAdc, I_B = 0) MJ4030, MJ4033		60	–	
MJ4031, MJ4034		80	–	
MJ4032, MJ4035		100	–	
Collector Emitter Leakage Current	I_{CER}			mAdc
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm) MJ4030, MJ4033		–	1.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm) MJ4031, MJ4034		–	1.0	
(V_{CB} = 100 Vdc, R_{BE} = 1.0 k ohm) MJ4032, MJ4035		–	1.0	
(V_{CB} = 60 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C) MJ4030, MJ4033		–	5.0	
(V_{CB} = 80 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C) MJ4031, MJ4034		–	5.0	
(V_{CB} = 100 Vdc, R_{BE} = 1.0 k ohm, T_C = 150°C) MJ4032, MJ4035		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
Collector-Emitter Leakage Current	I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0) MJ4030, MJ4033		–	3.0	
(V_{CE} = 40 Vdc, I_B = 0) MJ4031, MJ4034		–	3.0	
(V_{CE} = 50 Vdc, I_B = 0) MJ4032, MJ4035		–	3.0	
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 10 Adc, V_{CE} = 3.0 Vdc)	h_{FE}	1000	–	–
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 40 mAdc)		–	2.5	
(I_C = 16 Adc, I_B = 80 mAdc)		–	4.0	
Base-Emitter Voltage (I_C = 10 Adc, V_{CE} = 3.0 Vdc)	V_{BE}	–	3.0	Vdc

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

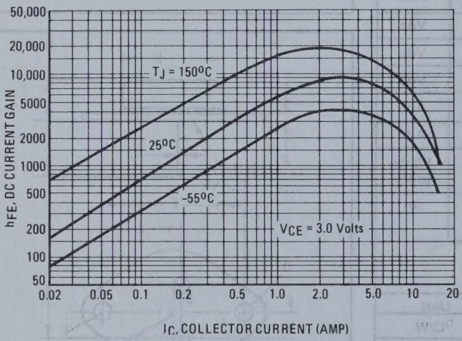


FIGURE 3 – SMALL-SIGNAL CURRENT GAIN

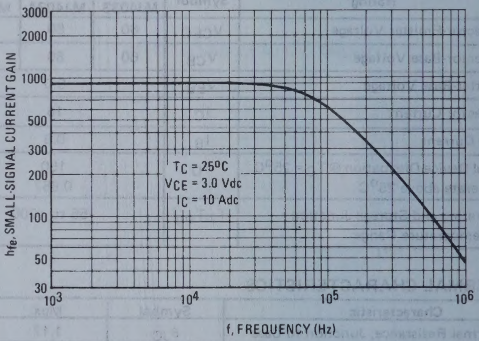


FIGURE 4 – "ON" VOLTAGES

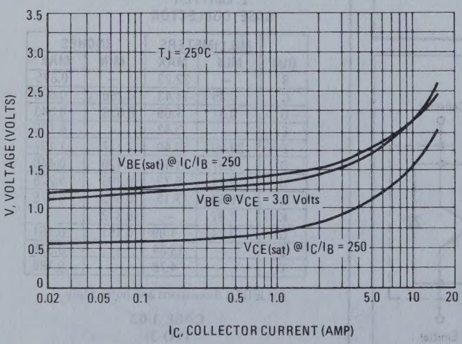
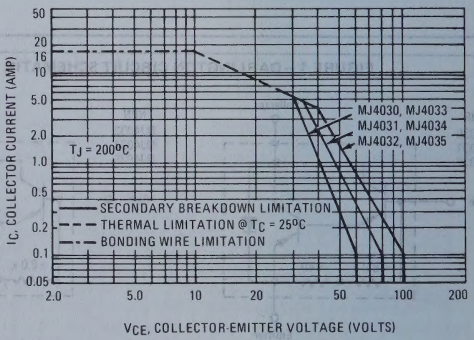


FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

MJ4200, MJ4201 NPN (SILICON)
MJ4210, MJ4211 PNP

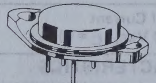
DUAL SILICON POWER DARLINGTON TRANSISTORS

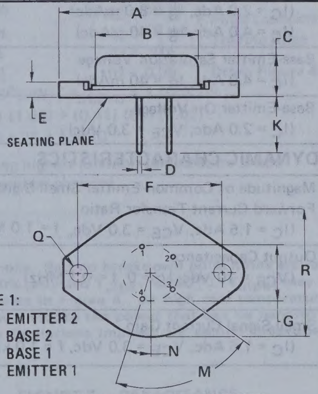
. . . designed for hammer driver, regulator and amplifier applications.

- High DC Current Gain — h_{FE} = 3000 (Typ) @ I_C = 2.0 Adc
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 60 Vdc — MJ4200, MJ4210
  = 80 Vdc — MJ4201, MJ4211
- Total Monolithic Construction
  Dual transistors in the same chip, yielding like electrical characteristics. Collectors are common

DUAL DARLINGTON
4 AMPERE
COMPLEMENTARY SILICON
POWER TRANSISTORS

60, 80 VOLTS
85 WATTS





STYLE 1:
PIN 1. EMITTER 2
2. BASE 2
3. BASE 1
4. EMITTER 1

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	38.61	–	1.520
B	–	21.08	–	0.830
C	6.35	8.13	0.250	0.320
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	11.94 BSC		0.470 BSC	
K	7.11	8.13	0.280	0.320
M	72° BSC		72° BSC	
N	18° BSC		18° BSC	
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) DIA OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

CASE 253

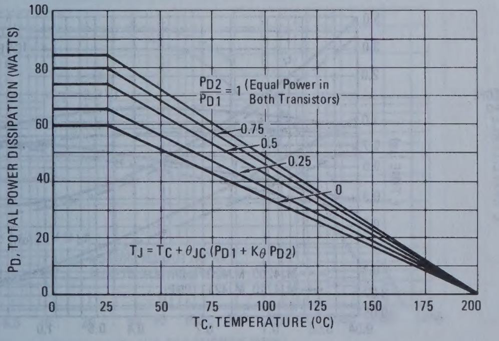
MAXIMUM RATINGS

Rating	Symbol	MJ4200 MJ4210	MJ4201 MJ4211	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous — Peak	I_C	4.0 8.0		Adc
Base Current	I_B	80		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C (Equal power in both transistors)	P_{DT}	85 0.485		Watts W/°C
Single Transistor Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 0.343		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65°C to +200°C		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case Single Transistor Effective, equal power both transistors	θ_{JC}	 2.92 2.06	°C/W
Thermal Coupling Factor	K_θ	41	%

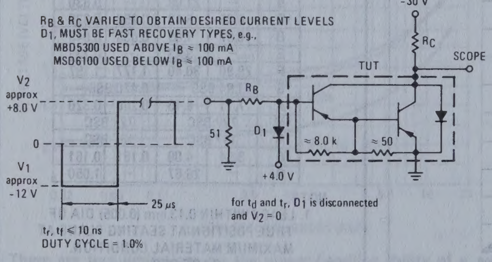
FIGURE 1 — POWER DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, I_B = 0)	MJ4200, MJ4210 MJ4201, MJ4211	$V_{CEO(sus)}$	60 80	— —	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0) (V_{CE} = 40 Vdc, I_B = 0)	MJ4200, MJ4210 MJ4201, MJ4211	I_{CEO}	— —	0.5 0.5	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ4200, MJ4201 MJ4210, MJ4211 MJ4200, MJ4201 MJ4210, MJ4211	I_{CEX}	— — — —	0.5 0.5 5.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 3.0 Vdc) (I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	750 100	18000 —	—
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 8.0 mAdc) (I_C = 4.0 Adc, I_B = 40 mAdc)		$V_{CE(sat)}$	— —	2.0 3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 40 mAdc)		$V_{BE(sat)}$	—	4.0	Vdc
Base-Emitter On Voltage (I_C = 2.0 Adc, V_{CE} = 3.0 Vdc)		$V_{BE(on)}$	—	2.8	Vdc
DYNAMIC CHARACTERISTICS					
Magnitude of Common-Emitter Small-Signal Short-Circuit Forward Current Transfer Ratio (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		$\lvert h_{fe} \rvert$	4.0	—	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJ4200, MJ4201 MJ4210, MJ4211	C_{ob}	— —	120 200	pF
Small-Signal Current Gain (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 kHz)		h_{fe}	300	—	—

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



R_B & R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS
D1, MUST BE FAST RECOVERY TYPES, e.g.,
MBD5300 USED ABOVE I_B ≈ 100 mA
MSD6100 USED BELOW I_B ≈ 100 mA
V_CC
-30 V
R_C
SCOPE
TUT
V2
approx
+8.0 V
0
V1
approx
-12 V
R_B
51
D1
≈ 8.0 k
≈ 50
+4.0 V
25 μs
for t_d and t_r, D1 is disconnected
and V2 = 0
t_r, t_f ≤ 10 ns
DUTY CYCLE = 1.0%

For NPN test circuit reverse all polarities.

FIGURE 3 – SWITCHING TIMES

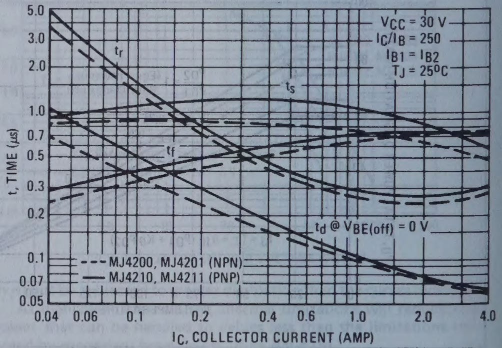


FIGURE 4 – THERMAL RESPONSE

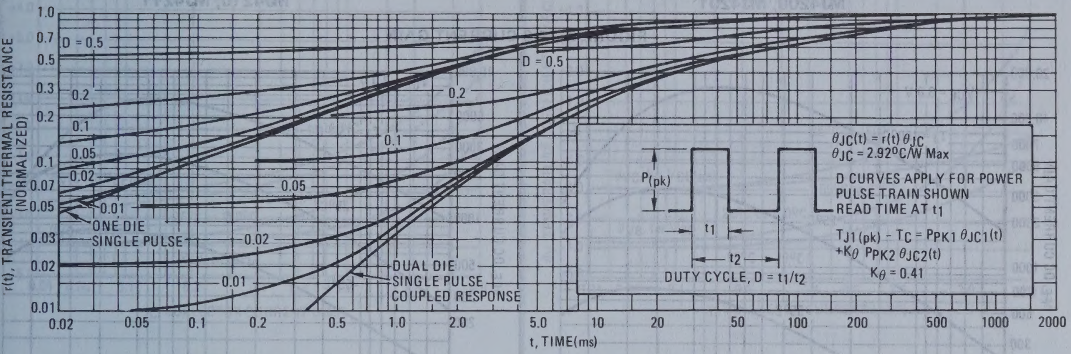
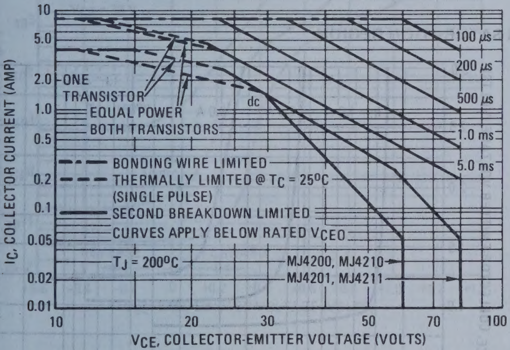


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



NOTE

Computing Peak Junction Temperature

Use $T_{J1(pk)} - T_C = P_{PK1}\,\theta_{JC1(t)} + K_\theta\,P_{PK2}\,\theta_{JC2(t)}$

Example: $P_{PK1} = 80$ W $\quad P_{PK2} = 50$ W
$t_1 = 5$ ms $\quad t_1 = 10$ ms $\Big\}$ Pulse Coincident at Trailing Edge
$D = 20\%$ $\quad D = 20\%$

Read $r(t) = 0.58$ $\quad r(t) = 0.35$ (from Figure 4)

$\therefore \theta_{JC1(t)} = 1.69°C/W \quad \therefore \theta_{JC2(t)} = 1.02°C/W$

$$T_{J1(pk)} - T_C = (80)\,(1.69) + (0.41)\,(50)\,(1.02)$$

$$= 135 + 21 = 156°C$$

Where the side having highest junction temperature is not obvious, both sides should be checked.

There are two limitations on the power handling ability of a transistor – average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – SMALL-SIGNAL CURRENT GAIN

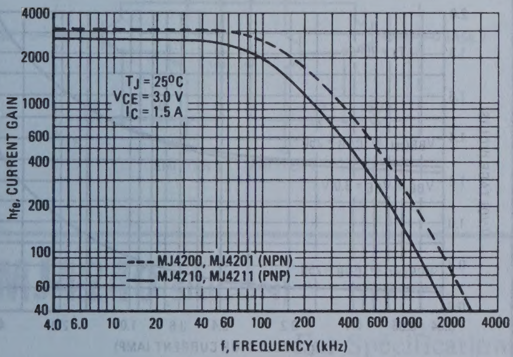
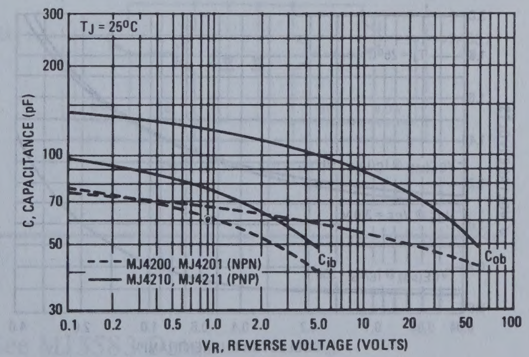


FIGURE 7 – CAPACITANCE



NPN
MJ4200, MJ4201

PNP
MJ4210, MJ4211

FIGURE 8 – DC CURRENT GAIN

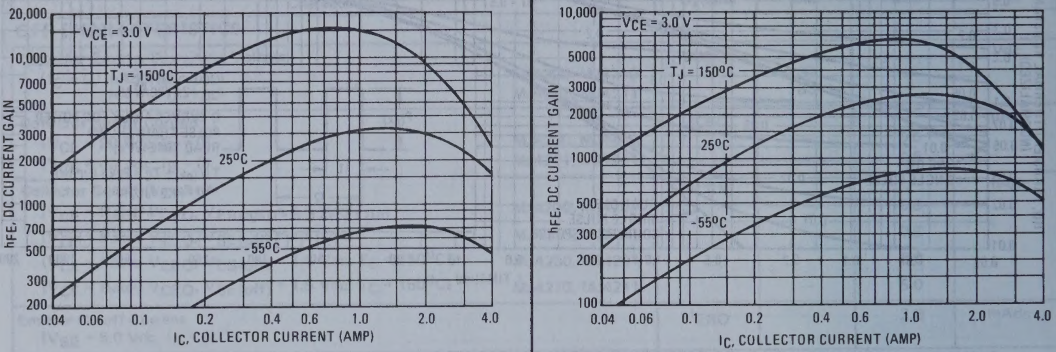


FIGURE 9 – COLLECTOR SATURATION REGION

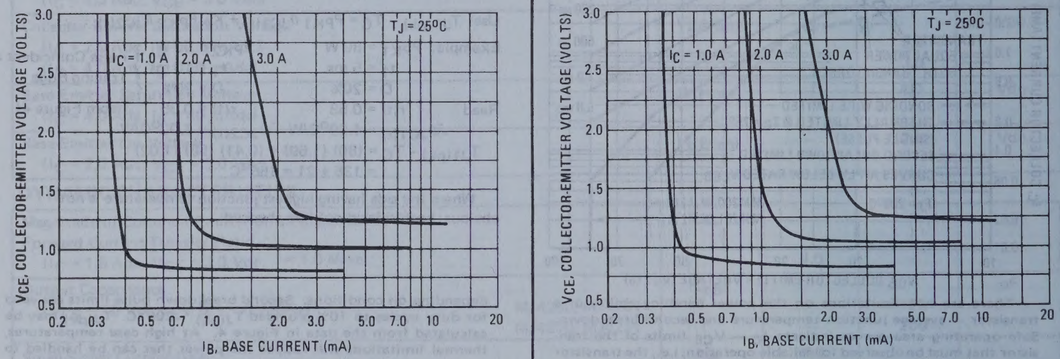
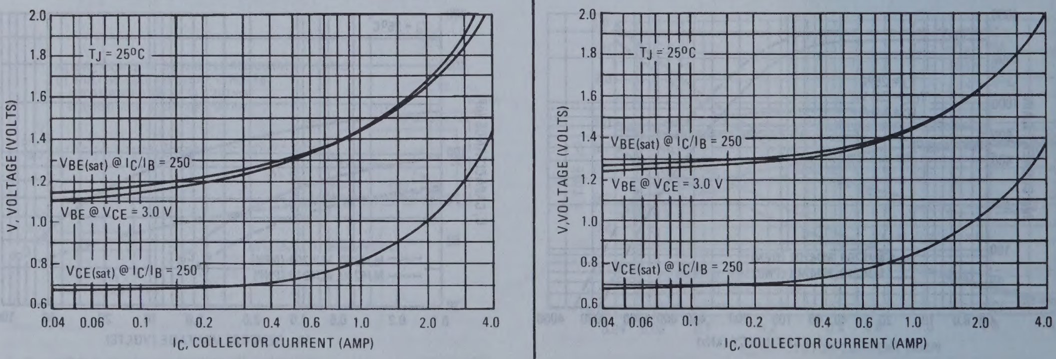


FIGURE 10 – ON VOLTAGES



NPN
MJ4200, MJ4201

PNP
MJ4210, MJ4211

FIGURE 11 – TEMPERATURE COEFFICIENTS

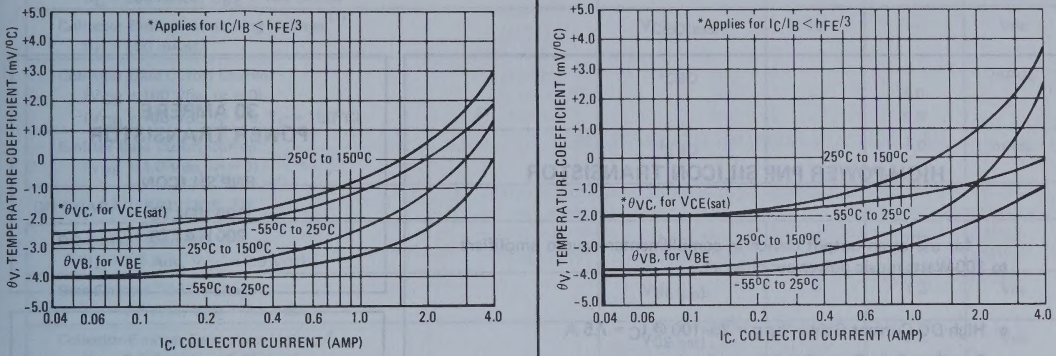


FIGURE 12 – COLLECTOR CUTOFF REGION

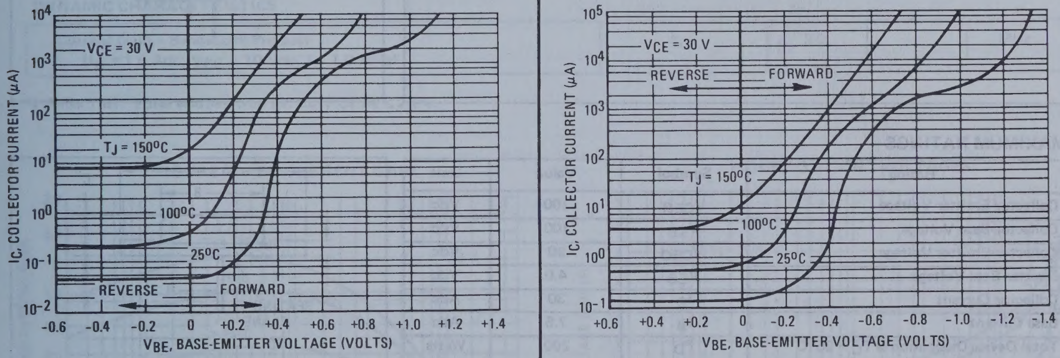
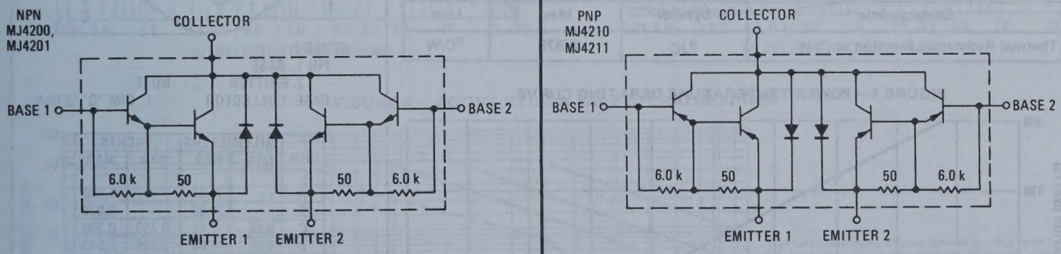


FIGURE 13 – DARLINGTON SCHEMATIC


NPN
MJ4200,
MJ4201
COLLECTOR
BASE 1
BASE 2
6.0 k
50
50
6.0 k
EMITTER 1
EMITTER 2
PNP
MJ4210
MJ4211
COLLECTOR
BASE 1
BASE 2
6.0 k
50
50
6.0 k
EMITTER 1
EMITTER 2

MJ4240 (SILICON)

For Specifications, See MJ3583 Data.

MJ4502 (SILICON)

HIGH-POWER PNP SILICON TRANSISTOR

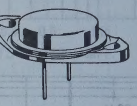
. . . for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25–100 @ I_C = 7.5 A
- Excellent Safe Operating Area
- Complement to the NPN MJ802

30 AMPERE
POWER TRANSISTOR

PNP SILICON

100 VOLTS
200 WATTS



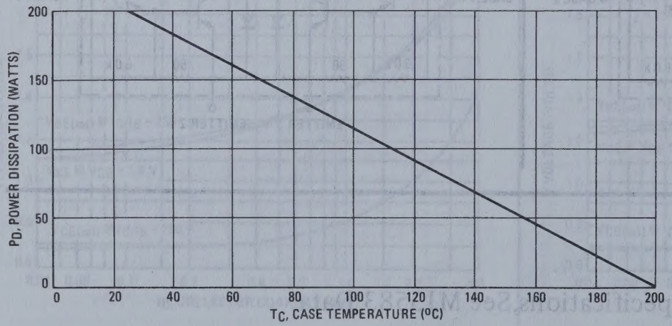
MAXIMUM RATINGS

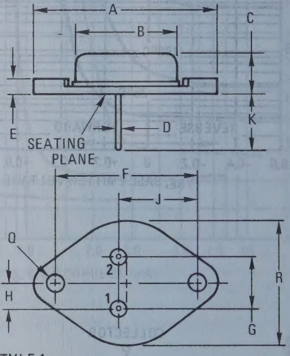
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CEO}	90	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	30	Adc
Base Current	I_B	7.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [(1)] (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}	100	–	Vdc
Collector-Emitter Sustaining Voltage [(1)] (I_C = 200 mAdc)	$V_{CEO(sus)}$	90	–	Vdc
Collector-Base Cutoff Current	I_{CBO}			mAdc
(V_{CB} = 100 Vdc, I_E = 0)		–	1.0	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)		–	5.0	
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS [(1)]				
DC Current Gain (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter "On" Voltage* (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.3	Vdc
Collector-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{CE(sat)}$	–	0.8	Vdc
Base-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{BE(sat)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

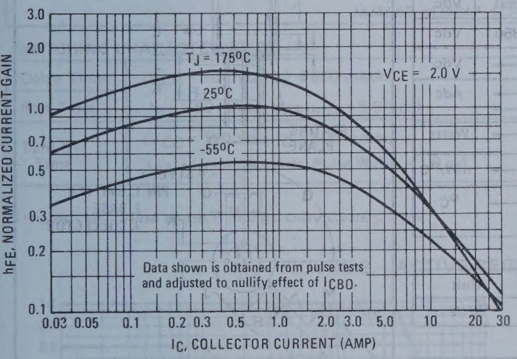


FIGURE 3 – "ON" VOLTAGES

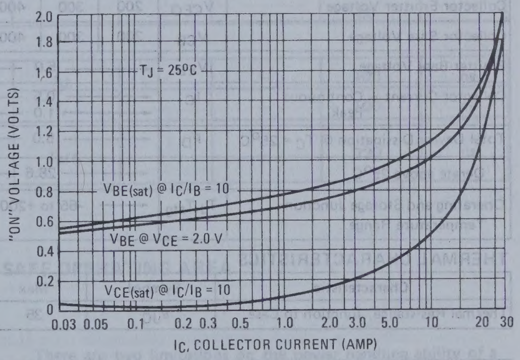
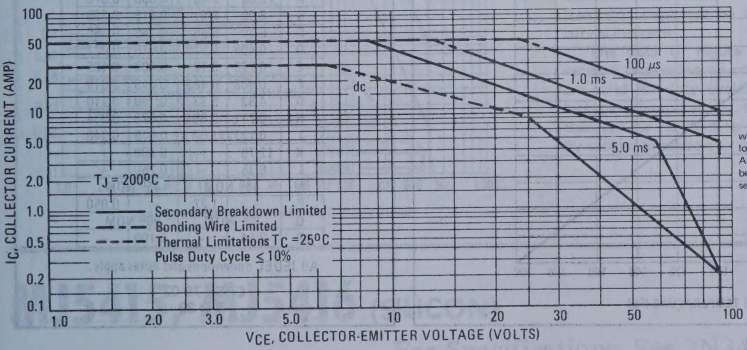


FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ4645 thru MJ4648 (SILICON)

PNP SILICON POWER TRANSISTORS

. . . designed for high-voltage amplifier and saturated switching applications at collector currents to one Ampere. Ideally suited for applications of dc-to-dc converters, relay and hammer drivers, motor controls, and servo and pulse amplifiers. High-voltage ratings permit direct-line operation.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = < 1.5$ Vdc (Max) @ $I_C = 500$ mAdc
- High Collector-Emitter Breakdown Voltage — $BV_{CEO} = 200, 300, 350$ and 400 Vdc (Min)
- DC Current Gain Specified — 10 mAdc to 500 mAdc

1.0 AMPERE
POWER TRANSISTORS
PNP SILICON
200-300-350-400 VOLTS
5 WATTS

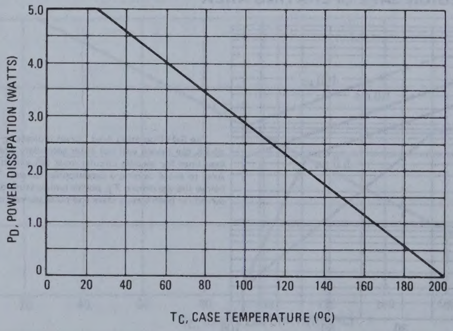
MAXIMUM RATINGS

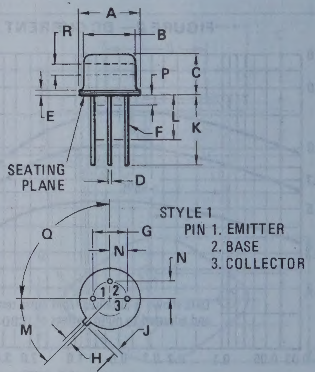
Rating	Symbol	MJ4645	MJ4646	MJ4647	MJ4648	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	400	350	Vdc
Collector-Base Voltage	V_{CB}	200	300	400	350	Vdc
Emitter-Base Voltage	V_{EB}	5.0				Vdc
Collector Current — Continuous Peak	I_C	0.5 1.0				Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$	P_D	5.0				Watts
Derate above 25°C		28.6				mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	°C/W

FIGURE 1 — POWER DERATING





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

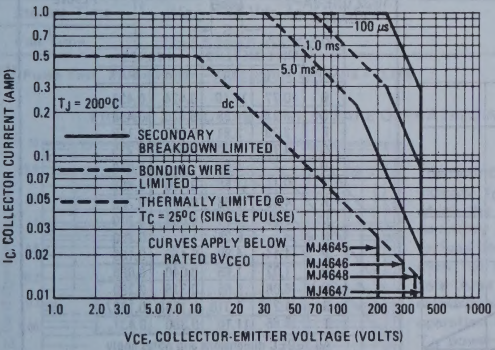
MJ4645 thru MJ4648 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}				Vdc
	MJ4645		200	–	–	
	MJ4646		300	–	–	
	MJ4647		400	–	–	
	MJ4648		350	–	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}				Vdc
	MJ4645		200	–	–	
	MJ4646		300	–	–	
	MJ4647		400	–	–	
	MJ4648		350	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 200 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		I_{CEX}	–	–	10	μAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			20	–	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc) (1)			25	–	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) (1)			20	–	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)		$V_{CE(sat)}$				Vdc
	MJ4645		–	0.5	1.0	
	MJ4646		–	0.6	1.2	
	MJ4647, MJ4648		–	0.75	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 70 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T				MHz
	MJ4645, MJ4646		40	–	–	
	MJ4647, MJ4648		30	–	–	
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}				pF
	MJ4645		–	–	80	
	MJ4646, MJ4647, MJ4648		–	–	60	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc,	t_d	–	–	100	ns
Rise Time	I_{B1} = 50 mAdc, $V_{BE(off)}$ = 5.0 Vdc)	t_r	–	–	100	ns
Turn-Off Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc, Pulse Width = 1.0 μs)	t_{off}	–	–	720	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C – V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant$ 200°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJ5415, MJ5416 (SILICON)

For Specifications, See 2N3439 Data, Volume I.

MJ6257 (SILICON) For Specifications, See MJ3771 Data.

MJ6302 (SILICON) For Specifications, See MJ3773 Data.

MJ6700, MJ6701 (SILICON)

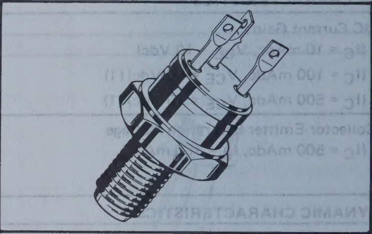
MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = 1.2$ Vdc (Max) @ $I_C = 7.0$ Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration — 700 V Breakdown

7 AMPERE
POWER TRANSISTORS
PNP SILICON

60-80 VOLTS
60 WATTS



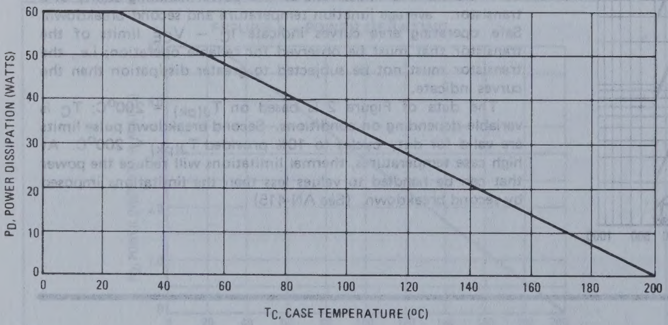
MAXIMUM RATINGS

Rating	Symbol	MJ6700	MJ6701	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above 25°C	P_D	60 343		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

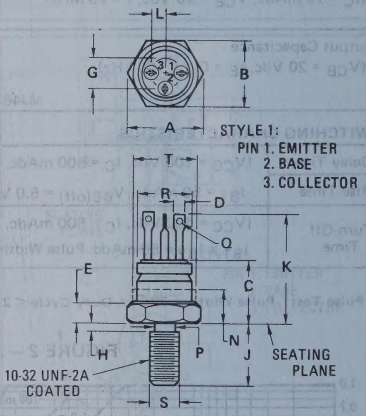
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	10.77	11.10	0.424	0.437
C	8.13	11.89	0.320	0.468
E	2.29	3.81	0.090	0.150
G	4.70	5.46	0.185	0.215
H	–	1.98	–	0.078
J	10.16	11.56	0.400	0.455
K	14.48	19.38	0.570	0.763
L	2.29	2.79	0.090	0.110
N	–	6.35	–	0.250
P	4.14	4.80	0.163	0.189
Q	1.02	1.65	0.040	0.065
R	8.08	9.65	0.318	0.380
S	4.212	4.310	0.1658	0.1697
T	9.65	11.10	0.380	0.437

All JEDEC dimensions and notes apply
Collector isolated from case.

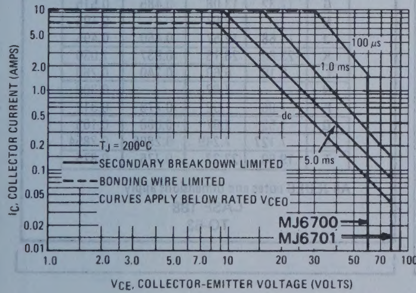
CASE 160-03
(TO-59)

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage [(1)]	$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0) MJ6700		60	–	
MJ6701		80	–	
Collector Cutoff Current	I_{CEO}			μAdc
(V_{CE} = 55 Vdc, I_B = 0) MJ6700		–	100	
(V_{CE} = 75 Vdc, I_B = 0) MJ6701		–	100	
Collector Cutoff Current	I_{CEX}			
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc) MJ6700		–	10	μAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc) MJ6701		–	10	
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) MJ6700		–	1.0	mAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) MJ6701		–	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS [(1)]				
DC Current Gain	h_{FE}			–
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		25	–	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)		25	180	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		15	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)		–	0.7	
(I_C = 7.0 Adc, I_B = 0.7 Adc)		–	1.2	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)		–	1.2	
(I_C = 7.0 Adc, I_B = 0.7 Adc)		–	2.0	
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)	f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc,	t_d	–	100	ns
Rise Time I_C = 2.0 Adc, I_{B1} = 200 mAdc)	t_r	–	100	ns
Storage Time (V_{CC} = 40 Vdc, I_C = 2.0 Adc,	t_s	–	1.0	μs
Fall Time I_{B1} = I_{B2} = 200 mAdc)	t_f	–	150	ns

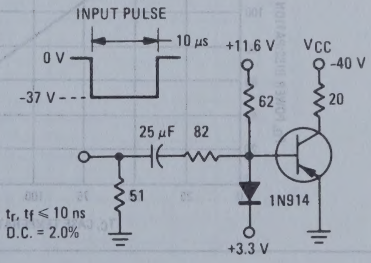
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ7000 (SILICON)

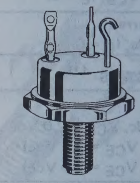
HIGH-POWER NPN SILICON TRANSISTOR

. . . designed for use in industrial power amplifier and switching circuits applications.

- High DC Current Gain – h_{FE} = 20-100 @ I_C = 10 Adc
- High Collector-Emitter Sustaining Voltage – $V_{CEO(sus)}$ = 100 Vdc (Min) @ I_C = 100 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 1.7 Vdc (Max) @ I_C = 30 Adc

30 AMPERE
POWER TRANSISTOR
NPN SILICON

100 VOLTS
150 WATTS

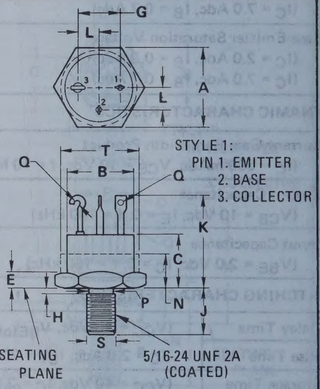


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	30	Adc
Base Current – Continuous	I_B	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.855	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W



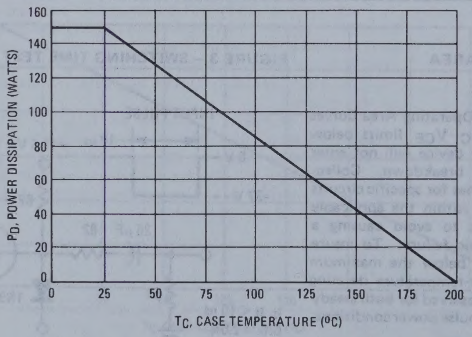
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	21.72	22.23	0.855	0.875
B	18.92	19.69	0.745	0.775
C	12.19	13.59	0.480	0.535
E	2.29	4.24	0.090	0.167
G	12.32	13.08	0.485	0.515
H	–	2.67	–	0.105
J	11.68	12.57	0.460	0.495
K	23.80	26.16	0.937	1.030
L	6.10	6.60	0.240	0.260
N	–	7.62	–	0.300
P	7.06	7.92	0.278	0.312
Q	1.52	2.67	0.060	0.105
S	7.127	7.249	0.2806	0.2854
T	19.69	22.23	0.775	0.875

All JEDEC notes and dimensions apply

CASE 188
TO-63

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage [1] (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	100	–	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 50 Vdc, I_B = 0)	I_{CEO}	–	10	μAdc
Collector-Emitter Cutoff Current (V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	5.0	μAdc
Collector-Base Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	I_{CBO}	–	5.0	μAdc
Emitter-Base Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	μAdc
ON CHARACTERISTICS [1]				
DC Current Gain	h_{FE}			
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		20	–	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)		20	100	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.0	
(I_C = 30 Adc, I_B = 4.0 Adc)		–	1.7	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.7	
(I_C = 30 Adc, I_B = 4.0 Adc)		–	2.25	
Base-Emitter On Voltage (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	600	pF

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MJ7160 (SILICON)
MJ7161

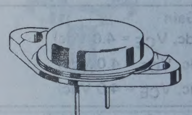
HIGH-POWER/HIGH-VOLTAGE TRIPLE DIFFUSED NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-frequency, line-operated switching applications.

- Excellent Switching Times — I_C = 5.0 Adc
  t_{on} = 200 ns (Typ)
  t_{off} = 1200 ns (Typ)
- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 3.0 Vdc (Max) @ I_C = 8.0 Adc
- Excellent Safe Operating Area Capability —
  $I_{S/b}$ = 0.2 Adc @ V_{CE} = 100 Volts

8.0 AMPERE
TRIPLE DIFFUSED
POWER TRANSISTORS
NPN SILICON

300-400 VOLTS
140 WATTS



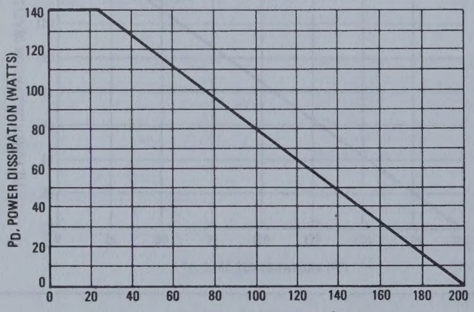
MAXIMUM RATINGS

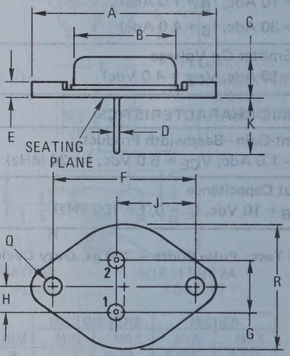
Rating	Symbol	MJ7160	MJ7161	Unit
Collector-Emitter Voltage	V_{CEO}	300	400	Vdc
Collector-Base Voltage	V_{CB}	325	425	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous Peak	I_C	8.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	140 0.80		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	°C/W

FIGURE 1 — POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

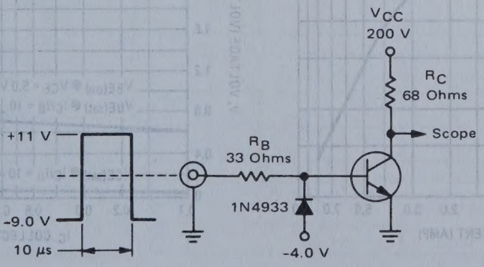
ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage	$V_{CEO(sus)}$			Vdc
($I_C = 10$ mAdc, $I_B = 0$) MJ7160		300	–	
($I_C = 10$ mAdc, $I_B = 0$) MJ7161		400	–	
Collector Cutoff Current	I_{CEX}			
($V_{CE} = 300$ Vdc, $V_{BE(off)} = 1.5$ Vdc) MJ7160		–	100	µAdc
($V_{CE} = 400$ Vdc, $V_{BE(off)} = 1.5$ Vdc) MJ7161		–	500	
($V_{CE} = 300$ Vdc, $V_{BE(off)} = 1.5$ Vdc, $T_C = 150^{\circ}C$) MJ7160		–	5.0	mAdc
($V_{CE} = 400$ Vdc, $V_{BE(off)} = 1.5$ Vdc, $T_C = 150^{\circ}C$) MJ7161		–	10	
Collector Cutoff Current	I_{CBO}			µAdc
($V_{CB} = 325$ Vdc, $I_E = 0$) MJ7160		–	100	
($V_{CB} = 425$ Vdc, $I_E = 0$) MJ7161		–	100	
Emitter Cutoff Current	I_{EBO}			µAdc
($V_{EB} = 6.0$ Vdc, $I_C = 0$)		–	100	
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			–
($I_C = 0.5$ Adc, $V_{CE} = 5.0$ Vdc) MJ7160,MJ7161		35	–	
($I_C = 3.0$ Adc, $V_{CE} = 5.0$ Vdc) MJ7160,MJ7161		25	100	
($I_C = 8.0$ Adc, $V_{CE} = 5.0$ Vdc) MJ7160		10	–	
MJ7161		5.0	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
($I_C = 3.0$ Adc, $I_B = 0.3$ Adc) MJ7160,MJ7161		–	1.0	
($I_C = 8.0$ Adc, $I_B = 1.6$ Adc) MJ7160		–	3.0	
($I_C = 8.0$ Adc, $I_B = 3.2$ Adc) MJ7161		–	3.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
($I_C = 3.0$ Adc, $I_B = 0.3$ Adc)		–	1.0	
($I_C = 8.0$ Adc, $I_B = 0.8$ Adc)		–	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (2) ($I_C = 0.5$ Adc, $V_{CE} = 10$ Vdc, $f_{test} = 10$ MHz)	f_T	30	–	MHz
Output Capacitance ($V_{CB} = 50$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	150	pF
Input Capacitance ($V_{EB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ib}	–	2000	pF
SWITCHING CHARACTERISTICS (Figure 2)				
Rise Time ($V_{CC} = 200$ Vdc, $I_C = 3.0$ Adc, $I_{B1} = I_{B2} = 0.3$ Adc)	t_r	–	200	ns
Storage Time	t_s	–	2.0	µs
Fall Time	t_f	–	300	ns

(1) Pulse Test: Pulse Width $\leqslant 300$ µs, Duty Cycle $\leqslant 2.0\%$.

(2) $f_T = |h_{fe}| \bullet f_{test}$.

FIGURE 2 — SWITCHING TIMES TEST CIRCUIT



t_r, $t_f \leqslant 10$ ns
Duty Cycle = 1.0%

*Values for R_B and R_C are varied to obtain the information for Figure 4.

FIGURE 3 – THERMAL RESPONSE

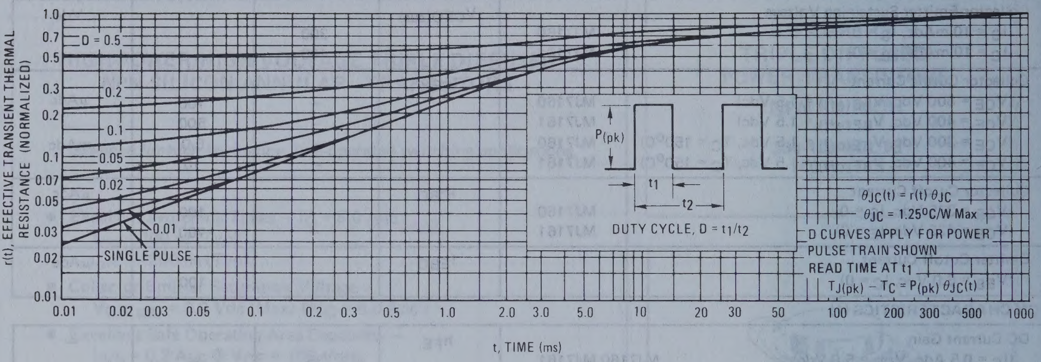
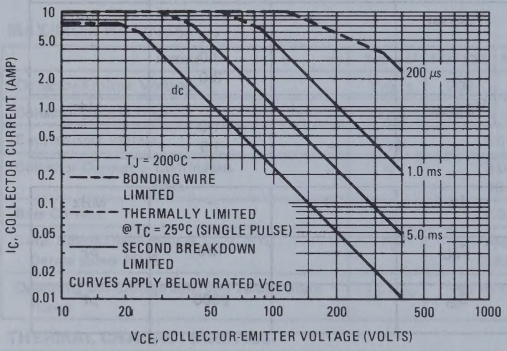


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 4 is based on $T_{J(pk)} = 200^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^\circ C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown (See AN-415).

FIGURE 5 – DC CURRENT GAIN

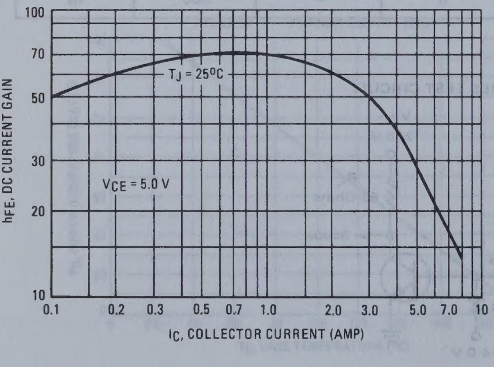


FIGURE 6 – "ON" VOLTAGES

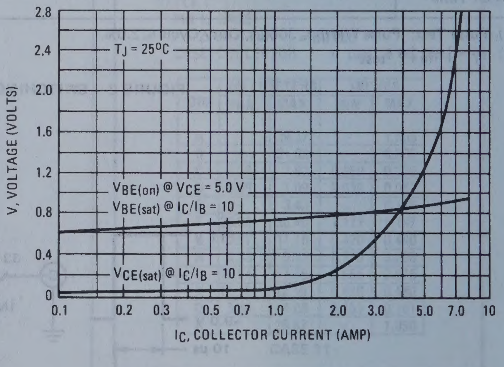


FIGURE 7 — SWITCHING TIMES

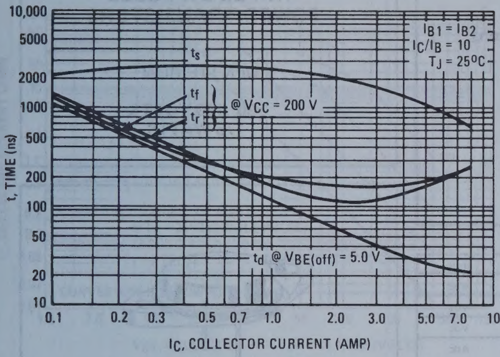
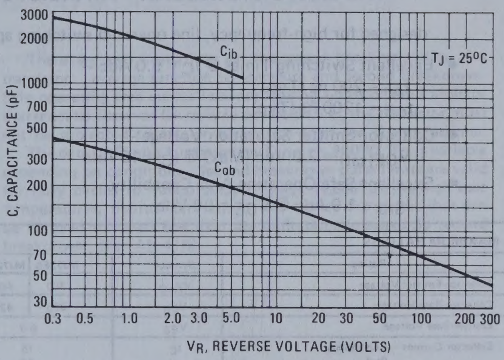


FIGURE 8 — CAPACITANCE



MJ7260 (SILICON)
MJ7261

HIGH-POWER/HIGH-VOLTAGE TRIPLE DIFFUSED NPN SILICON ANNULAR TRANSISTORS

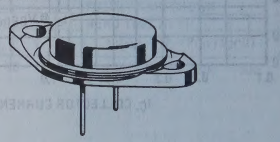
. . . designed for high-frequency, line operated switching applications.

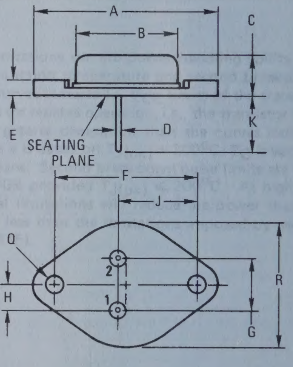
- Excellent Switching Times @ I_C = 5.0 Adc –
  t_{on} = 200 ns (Typ)
  t_{off} = 1200 ns (Typ)
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 2.0 Vdc (Max) @ I_C = 15 Adc
- Excellent Safe Operating Area Capability
  $I_{S/b}$ = 1.0 Adc @ V_{CE} = 50 Vdc

30 AMPERE
TRIPLE DIFFUSED
POWER TRANSISTORS

NPN SILICON

300, 400 VOLTS
175 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

MAXIMUM RATINGS

Rating	Symbol	MJ7260	MJ7261	Unit
Collector-Emitter Voltage	V_{CEO}	300	400	Vdc
Collector-Base Voltage	V_{CB}	325	425	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous Peak	I_C	15 30		Adc
Base Current	I_B	5.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	175 1.0		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

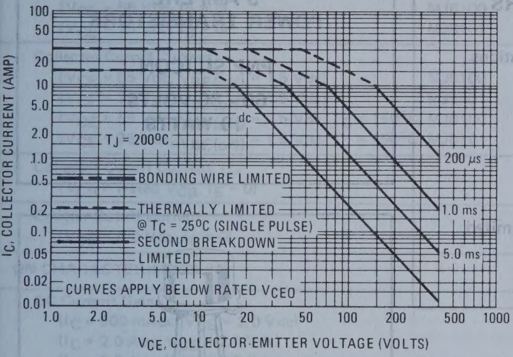
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	MJ7260 MJ7261	$V_{CEO(sus)}$	300 400	– –	Vdc
Collector Cutoff Current (V_{CE} = 300 Vdc, $V_{BE(off)}$ = –1.5 Vdc) (V_{CE} = 400 Vdc, $V_{BE(off)}$ = –1.5 Vdc) (V_{CE} = 300 Vdc, $V_{BE(off)}$ = –1.5 Vdc, T_C = 150°C) (V_{CE} = 400 Vdc, $V_{BE(off)}$ = –1.5 Vdc, T_C = 150°C)	MJ7260 MJ7261 MJ7260 MJ7261	I_{CEX}	– – – –	100 500 5.0 10	μAdc mAdc
Collector Cutoff Current (V_{CB} = 325 Vdc, I_E = 0) (V_{CB} = 425 Vdc, I_E = 0)	MJ7260 MJ7261	I_{CBO}	– –	100 100	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 15 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	30 25 5.0	– 100 –	–
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 500 mAdc) (I_C = 15 Adc, I_B = 5.0 Adc)		$V_{CE(sat)}$	– –	1.0 2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 500 mAdc) (I_C = 15 Adc, I_B = 1.5 Adc)		$V_{BE(sat)}$	– –	1.2 1.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 50 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	175	pF
Input Capacitance (V_{EB} = 5.0 Vdc, I_C = 0, f = 0.1 MHz)		C_{ib}	–	3500	pF

SWITCHING CHARACTERISTICS

		Symbol	Min	Max	Unit
Rise Time	(V_{CC} = 200 Vdc, I_C = 5.0 Adc, I_{B1} = I_{B2} = 0.5 Adc, $V_{BE(off)} \approx 5.0$ Vdc)	t_r	–	200	ns
Storage Time		t_s	–	2.0	μs
Fall Time		t_f	–	300	ns

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200^{\circ}C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 2 – DC CURRENT GAIN

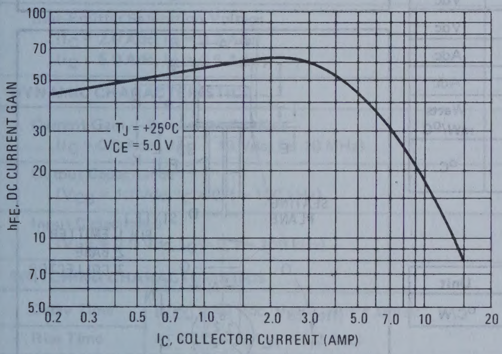


FIGURE 3 – ON VOLTAGES

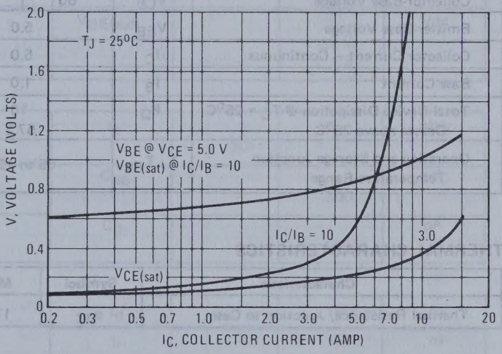


FIGURE 4 – SWITCHING TIMES

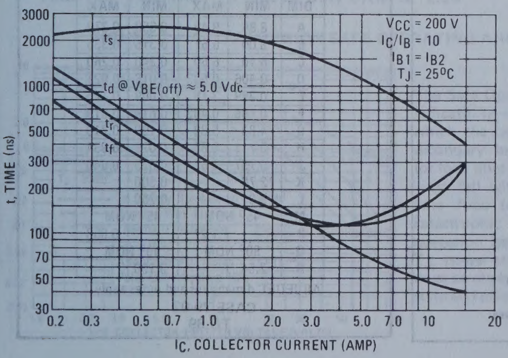
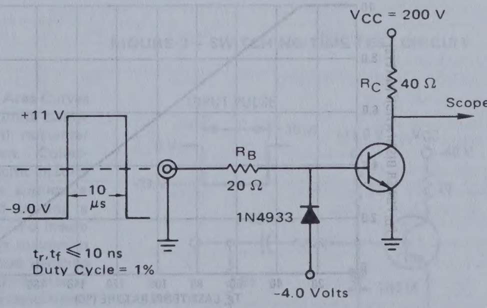


FIGURE 5 – SWITCHING TIMES TEST CIRCUIT



NOTE: For information on Figure 4, R_B and R_C were varied to obtain desired test conditions.

MJ8100 (SILICON)
MJ8101

MEDIUM-POWER PNP SILICON TRANSISTORS

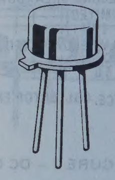
. . . designed for switching and wide band amplifier applications.

- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 5.0 Amp
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space-Limited Applications.

5 AMPERE
POWER TRANSISTORS

PNP SILICON

60 - 80 VOLTS
10 WATTS

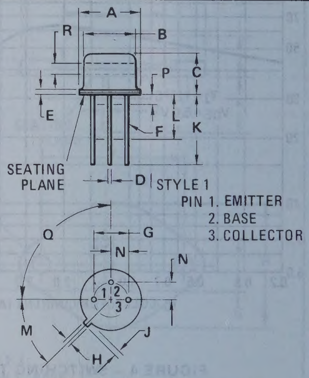


MAXIMUM RATINGS

Rating	Symbol	MJ8100	MJ8101	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57.2		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W

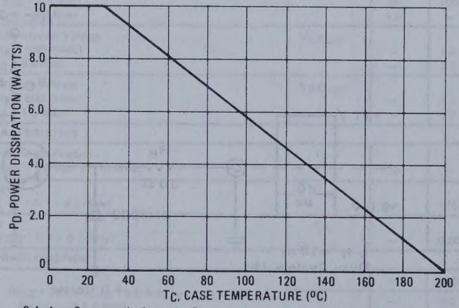


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



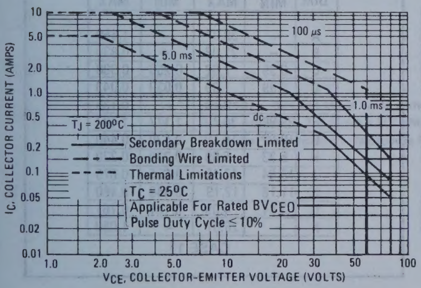
Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage [1] (I_C = 50 mAdc, I_B = 0)	MJ8100 MJ8101	$V_{CEO(sus)}$	60 80	– –	Vdc
Collector Cutoff Current (V_{CE} = 55 Vdc, I_B = 0) (V_{CE} = 75 Vdc, I_B = 0)	MJ8100 MJ8101	I_{CEO}	– –	100 100	μAdc
Collector Cutoff Current (V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ8100 MJ8101	I_{CEX}	– –	10 10	μAdc
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ8100 MJ8101		– –	1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	25 25 15	– 180 –	–
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{CE(sat)}$	– –	0.7 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{BE(sat)}$	– –	1.2 1.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc,	t_d	–	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 0.2 Adc)	t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	t_s	–	1.0	μs
Fall Time	I_{B1} = I_{B2} = 0.2 Adc)	t_f	–	150	ns

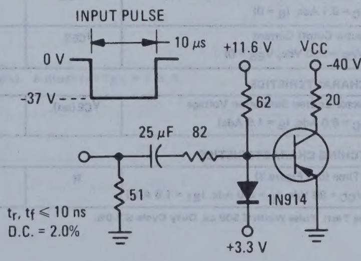
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ9000 (SILICON)

HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for single unit use in color horizontal deflection output circuits in television receivers.

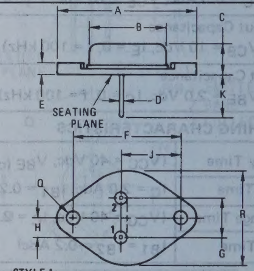
- High Collector-Emitter Voltage – V_{CES} = 700 Vdc
- Fast Fall Time – t_f = 1.1 µs (Max) @ I_C = 6.0 Adc

10 AMPERE
POWER TRANSISTOR

NPN SILICON

700 VOLTS
125 WATTS

DS 3157



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	325	Vdc
Collector-Emitter Voltage	V_{CES}	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

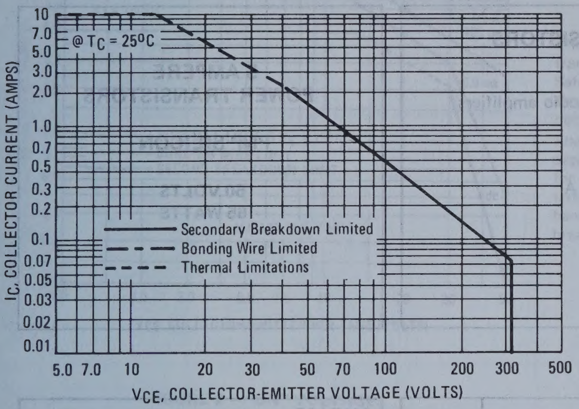
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 0.1 Adc, I_B = 0)	BV_{CEO}	325	–	Vdc
Collector Cutoff Current (V_{CE} = 700 Vdc, V_{EB} = 0)	I_{CES}	–	1.0	mAdc
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 6.0 Adc, I_B = 1.6 Adc)	$V_{CE(sat)}$	–	2.0	Vdc
SWITCHING CHARACTERISTICS				
Fall Time (See Figure 3) (V_{CC} = 80 Vdc, I_C = 6.0 Adc, I_{B1} = 1.6 Adc)	t_f	–	1.1	µs

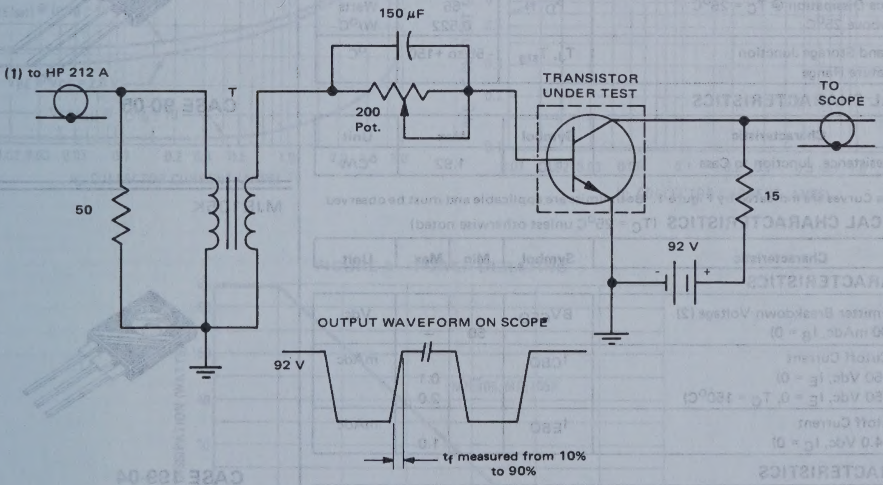
(1) Pulse Test: Pulse Width ≤ 500 µs, Duty Cycle ≤ 2.0%.

FIGURE 1 – ACTIVE-REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – TEST CIRCUIT FOR FALL TIME


150 µF
(1) to HP 212 A
T
200 Pot.
TRANSISTOR UNDER TEST
TO SCOPE
50
15
92 V
-
+
OUTPUT WAVEFORM ON SCOPE
92 V
t_f measured from 10% to 90%

(1) HP 212A: Set for 10 µs wide pulses at 2000 pulses per sec. (500 µs intervals). Adjust for I_{B1} = 1.6 A.
Bias: Adjust to 1.5 V on a VTVM across the 200 Ω Pot.
T: Pulse Transformer: Motorola Part No. 25D68782A01.

MJE105 (SILICON)
MJE105K

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 2.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to NPN MJE205, MJE205K
- Choice of Packages – MJE105 – Case 90
  MJE105K – Case 199

5 AMPERE
POWER TRANSISTORS

PNP SILICON

50 VOLTS
65 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	5.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D(1)	65 0.522	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.92	°C/W

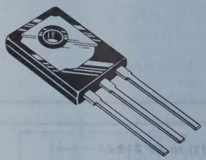
(1) Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	50	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	– –	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter Voltage (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	–	1.2	Vdc

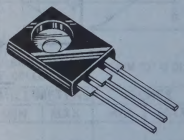
(2) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MJE105



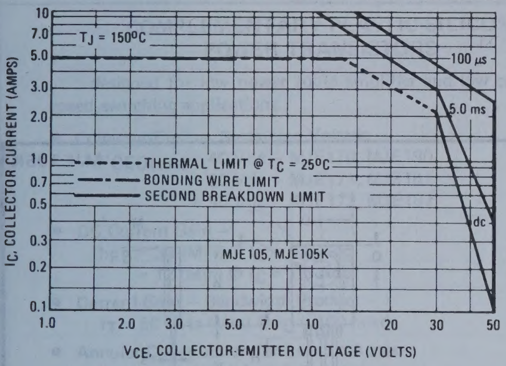
CASE 90-05

MJE105K



CASE 199-04

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate. The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – "ON" VOLTAGES

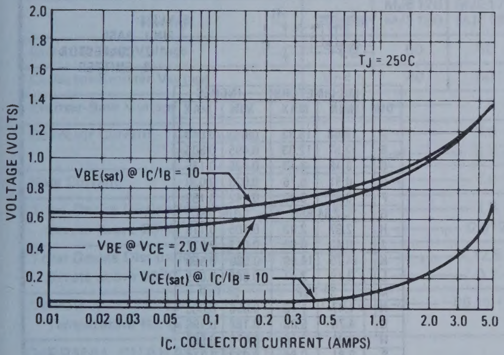


FIGURE 3 – DC CURRENT GAIN

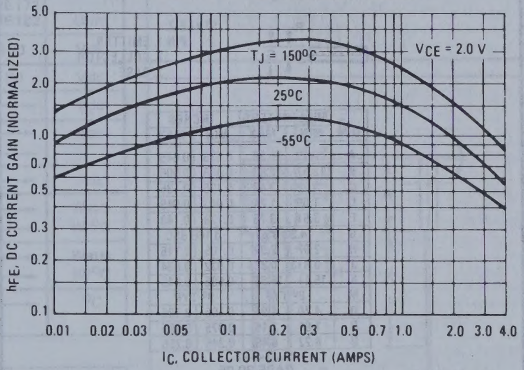
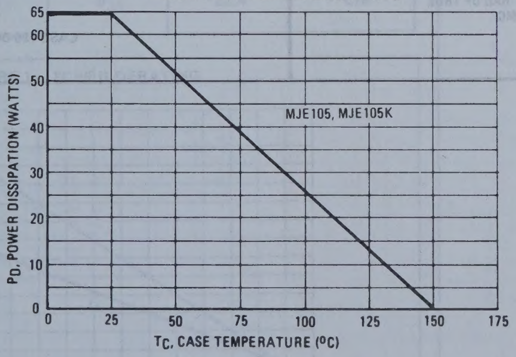
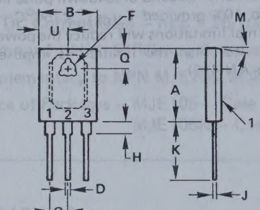
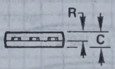


FIGURE 4 – POWER DERATING



MJE105





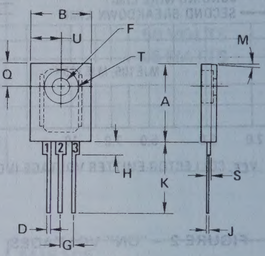
STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

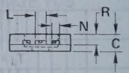
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

CASE 90-05

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

MJE105K





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

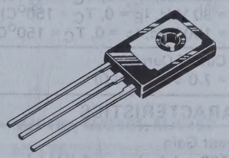
MJE170 thru MJE172 PNP (SILICON)
MJE180 thru MJE182 NPN

COMPLEMENTARY PLASTIC SILICON POWER TRANSISTORS

. . . designed for low power audio amplifier and low current, high speed switching applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 40 Vdc – MJE170, MJE180
  = 60 Vdc – MJE171, MJE181
  = 80 Vdc – MJE172, MJE182
- DC Current Gain —
  h_{FE} = 30 (Min) @ I_C = 0.5 Adc
  = 12 (Min) @ I_C = 1.5 Adc
- Current-Gain — Bandwidth Product —
  f_T = 50 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakages —
  I_{CBO} = 100 nA (Max) @ Rated V_{CB}

3 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
40-60-80 VOLTS
12.5 WATTS

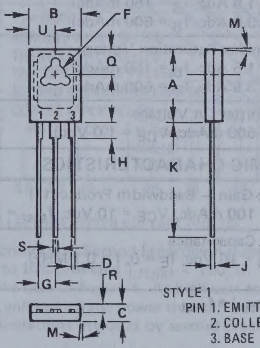


MAXIMUM RATINGS

Rating	Symbol	MJE170 MJE180	MJE171 MJE181	MJE172 MJE182	Unit
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current — Continuous Peak	I_C	← 3.0 → ← 6.0 →			Adc
Base Current	I_B	← 1.0 →			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 1.5 → ← 0.012 →			Watts W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 12.5 → ← 0.1 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	10	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W

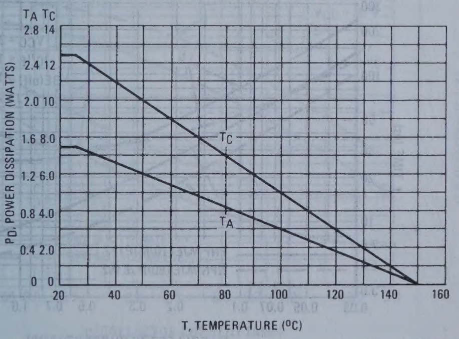


STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3^0 TYP		3^0 TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

FIGURE 1 — POWER DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

OFF CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	MJE170, MJE180	$V_{CEO(sus)}$	40	—	Vdc
	MJE171, MJE181		60	—	
	MJE172, MJE182		80	—	
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	MJE170, MJE180	I_{CBO}	—	0.1	µAdc
(V_{CB} = 80 Vdc, I_E = 0)	MJE171, MJE181		—	0.1	
(V_{CB} = 100 Vdc, I_E = 0)	MJE172, MJE182		—	0.1	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJE170, MJE180		—	0.1	mAdc
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJE171, MJE181		—	0.1	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)	MJE172, MJE182		—	0.1	
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	µAdc

ON CHARACTERISTICS

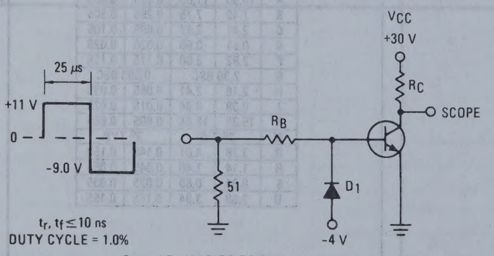
Characteristic		Symbol	Min	Max	Unit
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	50	250	—
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			30	—	
(I_C = 1.5 Adc, V_{CE} = 1.0 Vdc)			12	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	0.3	Vdc
(I_C = 1.5 Adc, I_B = 150 mAdc)			—	0.9	
(I_C = 3.0 Adc, I_B = 600 mAdc)			—	1.7	
Base-Emitter Saturation Voltage (I_C = 1.5 Adc, I_B = 150 mAdc)		$V_{BE(sat)}$	—	1.5	Vdc
(I_C = 3.0 Adc, I_B = 600 mAdc)			—	2.0	
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.2	Vdc

DYNAMIC CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Current-Gain — Bandwidth Product (1) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)		f_T	50	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJE170/MJE172	C_{ob}	—	50	pF
	MJE180/MJE182		—	30	

(1) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 — SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx$ 100 mA
MSD6100 USED BELOW $I_B \approx$ 100 mA

For PNP test circuit, reverse all polarities.

FIGURE 3 — TURN-ON TIME

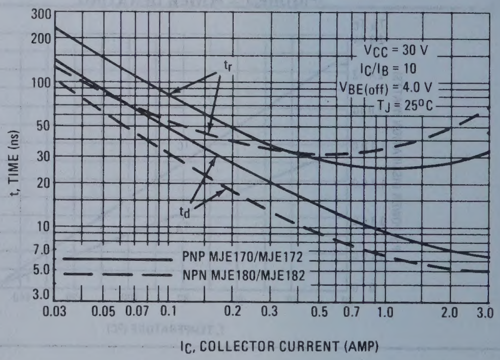
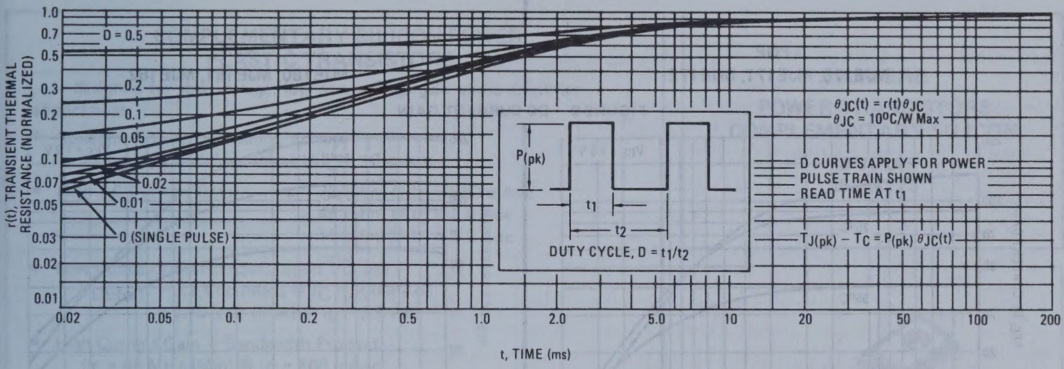


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – MJE170, MJE171, MJE172

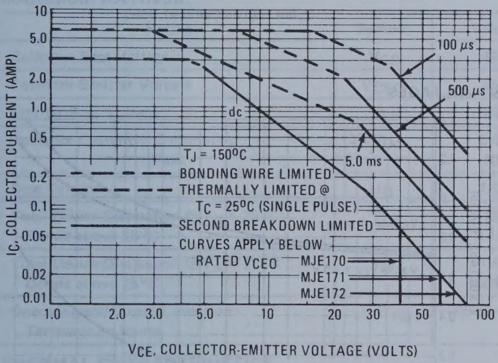
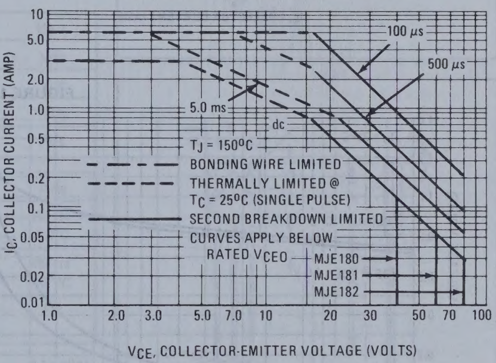


FIGURE 6 – MJE180, MJE181, MJE182



There are two limitations on the power handling ability of a transistor – average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 150^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 150^\circ C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperature, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – TURN-OFF TIME

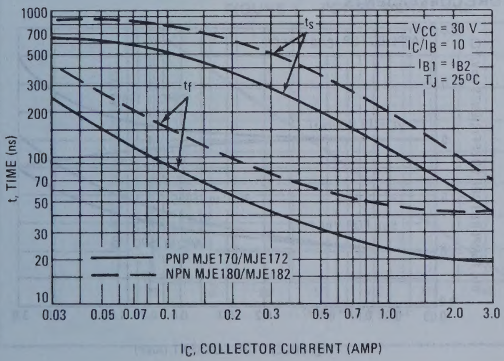
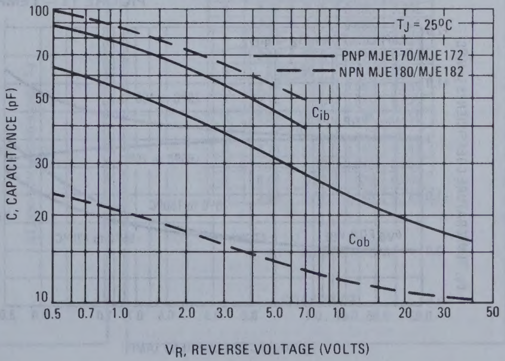


FIGURE 8 – CAPACITANCE



PNP
MJE170, MJE171, MJE172

NPN
MJE180, MJE181, MJE182

FIGURE 9 – DC CURRENT GAIN

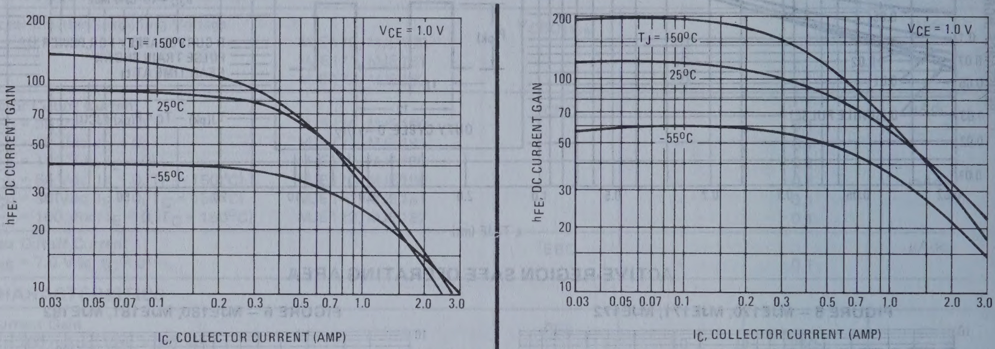


FIGURE 10 – "ON" VOLTAGES

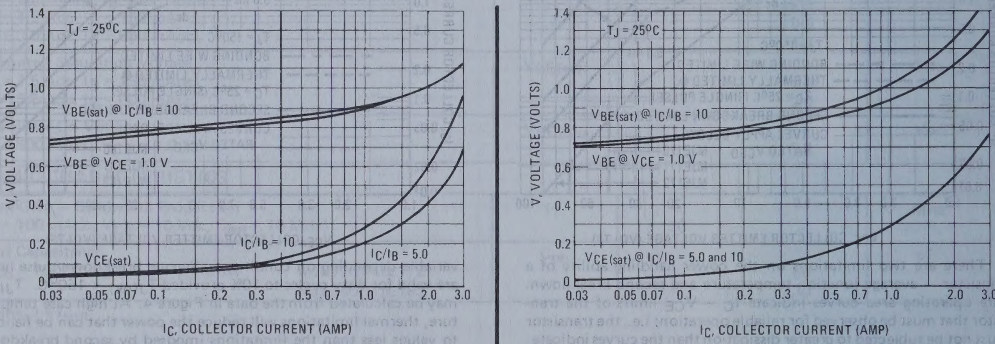
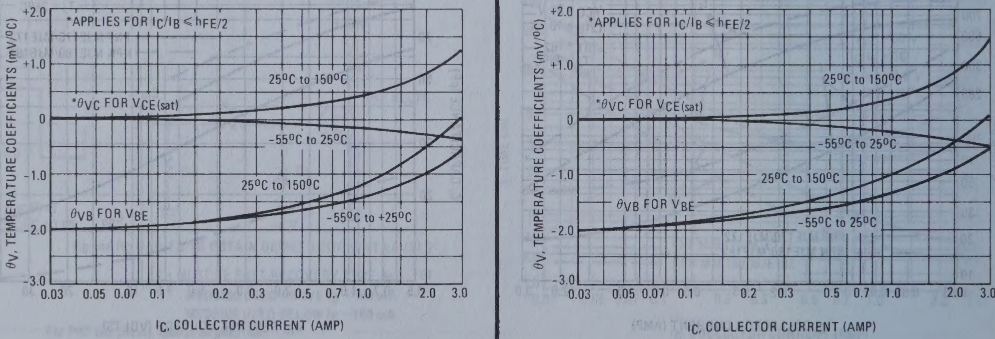


FIGURE 11 – TEMPERATURE COEFFICIENTS



MJE200 NPN (SILICON)
MJE210 PNP

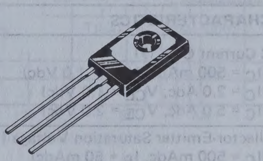
COMPLEMENTARY SILICON POWER PLASTIC TRANSISTORS

. . . designed for low voltage, low-power, high-gain audio amplifier applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 25 Vdc (Min) @ I_C = 10 mAdc
- High DC Current Gain — h_{FE} = 70 (Min) @ I_C = 500 mAdc
  = 45 (Min) @ I_C = 2.0 Adc
  = 10 (Min) @ I_C = 5.0 Adc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 500 mAdc
  = 0.75 Vdc (Max) @ I_C = 2.0 Adc
- High Current-Gain — Bandwidth Product —
  f_T = 65 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakage — I_{CBO} = 100 nAdc @ Rated V_{CB}

5 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

25 VOLTS
15 WATTS

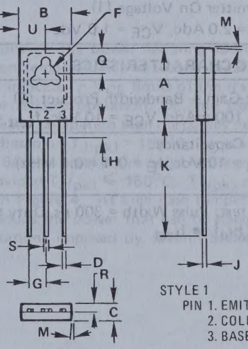


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current — Continuous Peak	I_C	5.0 10	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12	Watts W/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 0.012	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.34	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W



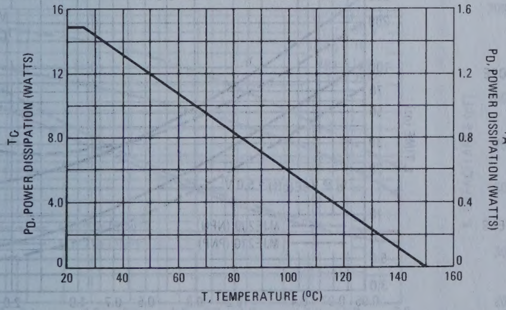
STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

NOTE:
1. MT = MAIN TERMINAL

CASE 77-03

FIGURE 1 — POWER DERATING

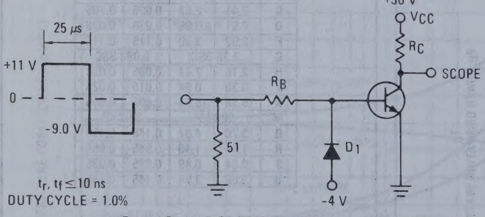


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	25	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_J = 125°C)	I_{CBO}	— —	100 100	nAdc µAdc
Emitter Cutoff Current (V_{BE} = 8.0 Vdc, I_C = 0)	I_{EBO}	—	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 1.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	70 45 10	— 180 —	—
Collector-Emitter Saturation Voltage (1) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 2.0 Adc, I_B = 200 mAdc) (I_C = 5.0 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	— — —	0.3 0.75 1.8	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 5.0 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	—	2.5	Vdc
Base-Emitter On Voltage (1) (I_C = 2.0 Adc, V_{CE} = 1.0 Vdc	$V_{BE(on)}$	—	1.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (2) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)	f_T	65	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz) MJE200 MJE210	C_{ob}	— —	80 120	pF

(1) Pulse test: Pulse Width = 300 µs, Duty Cycle ≈ 2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES

FIGURE 3 – TURN-ON TIME

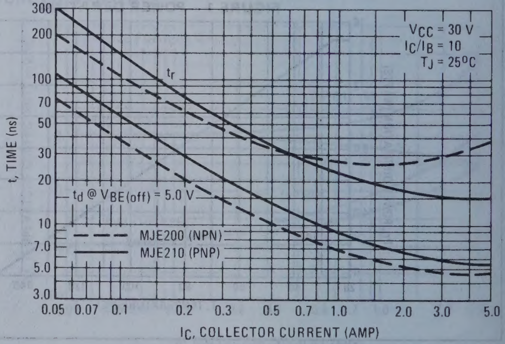


FIGURE 4 – THERMAL RESPONSE

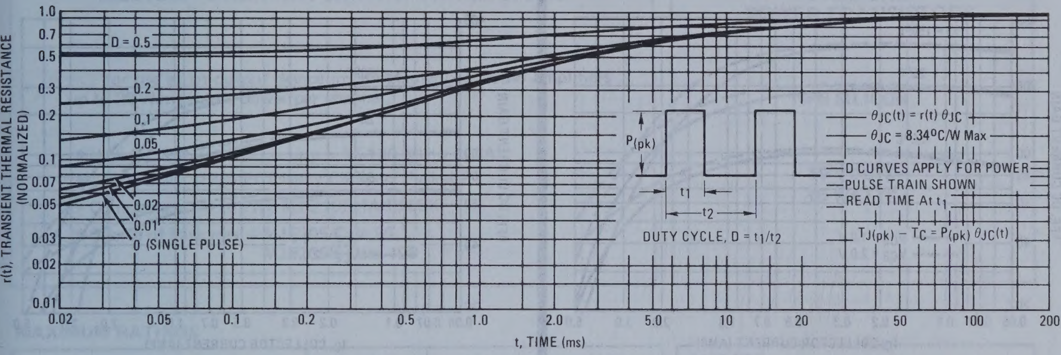
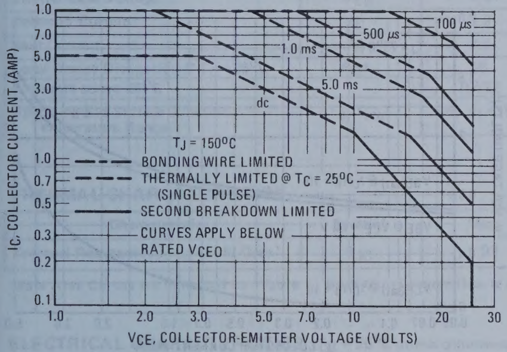


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

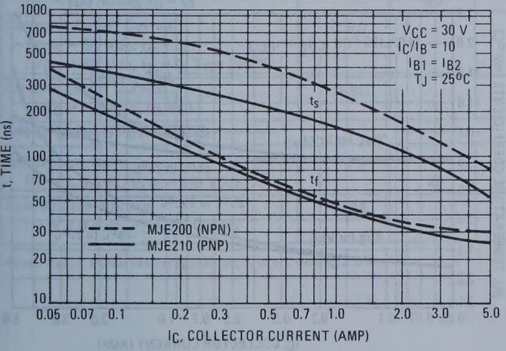
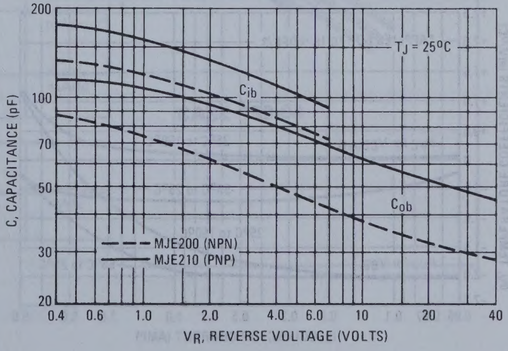


FIGURE 7 – CAPACITANCE



NPN
MJE200

PNP
MJE210

FIGURE 8 — DC CURRENT GAIN

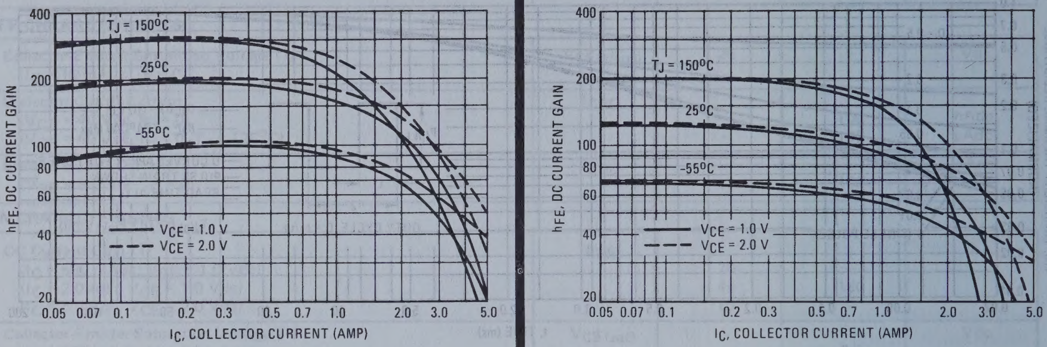


FIGURE 9 — "ON" VOLTAGE

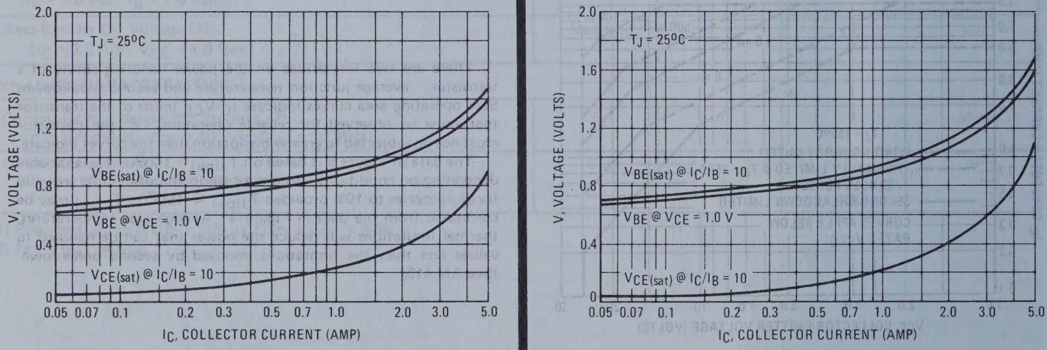
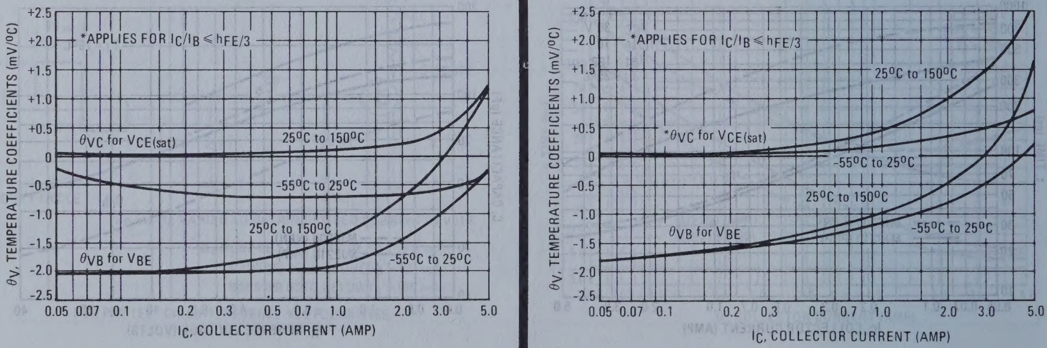


FIGURE 10 — TEMPERATURE COEFFICIENTS



MJE205 (SILICON)
MJE205K

MEDIUM-POWER NPN SILICON TRANSISTORS

. . . for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain — h_{FE} = 25-100 @ I_C = 2.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to PNP MJE 105, MJE105K
- Choice of Packages — MJE205-Case 90
  MJE205K-Case 199

5 AMPERE
POWER TRANSISTORS

NPN SILICON

50 VOLTS
65 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	5.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	65 0.522	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.92	°C/W

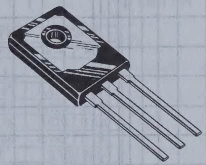
†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage‡ (I_C = 100 mAdc, I_B = 0)	BV_{CEO}‡	50	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	— —	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	—
Base-Emitter Voltage (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	—	1.2	Vdc

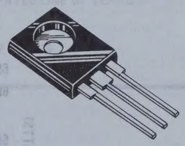
‡Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

MJE205



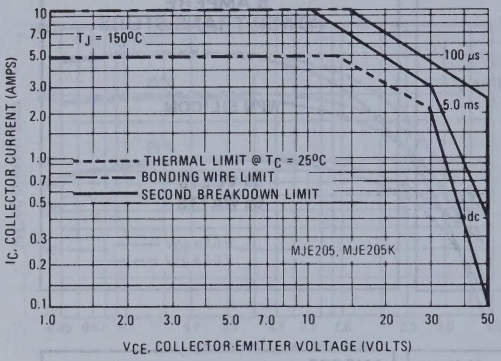
CASE 90-05

MJE205K



CASE 199-04

FIGURE 1 – ACTIVE REGION SAFE OPERATING AREA



Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – "ON" VOLTAGES

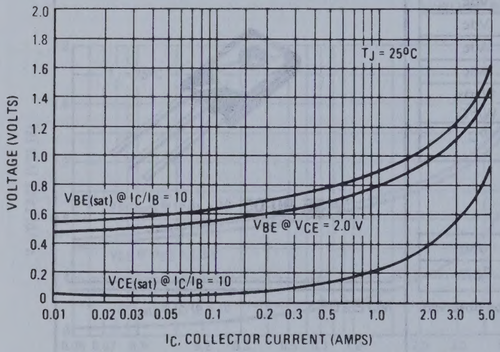


FIGURE 3 – DC CURRENT GAIN

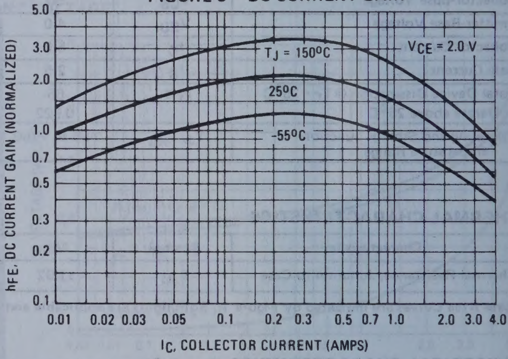
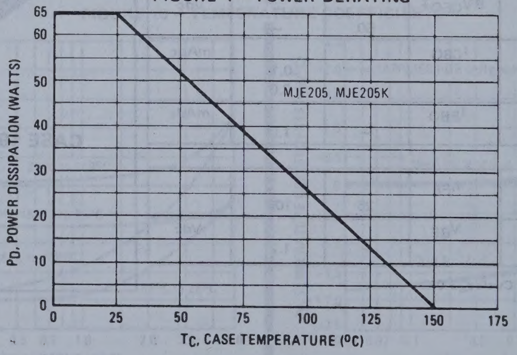
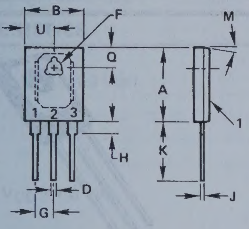
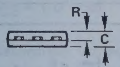


FIGURE 4 – POWER DERATING



MJE205





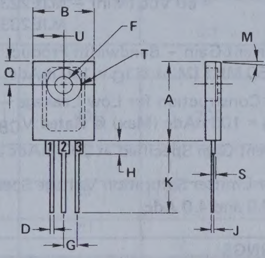
STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

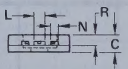
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

CASE 90-05

MJE205K





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE210 (SILICON)

For Specifications, See MJE200 Data.

MJE220 thru MJE225 NPN (SILICON)
MJE230 thru MJE235 PNP

COMPLEMENTARY PLASTIC SILICON POWER TRANSISTORS

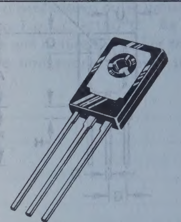
. . . designed for low power audio amplifier and low current, high-speed switching applications.

- Low Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 40 Vdc (Min) — MJE220/MJE222
  MJE230/MJE232
  = 60 Vdc (Min) — MJE223/MJE225
  MJE233/MJE235
- High Current-Gain — Bandwidth Product —
  f_T = 50 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakage —
  I_{CBO} = 100 nAdc (Max) @ Rated V_{CB}
- DC Current Gain Specified at 200 mAdc and 1.0 or 2.0 Adc
- Collector-Emitter Saturation Voltage Specified at 500 mAdc and 1.0, 2.0 and 4.0 Adc.

4 AMPERE
POWER TRANSISTORS

COMPLEMENTARY SILICON

40, 60 VOLTS
15 WATTS



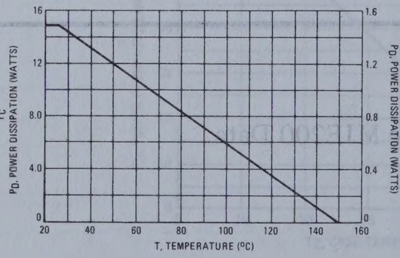
MAXIMUM RATINGS

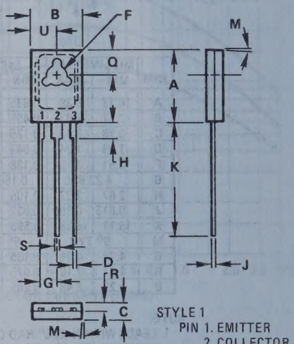
Rating	Symbol	MJE220 MJE221 MJE222 MJE230 MJE231 MJE232	MJE223 MJE224 MJE225 MJE233 MJE234 MJE235	Unit
Collector-Base Voltage	V_{CB}	60	80	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 8.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12		Watts W/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 0.012		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.34	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W

FIGURE 1 — POWER DERATING





STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

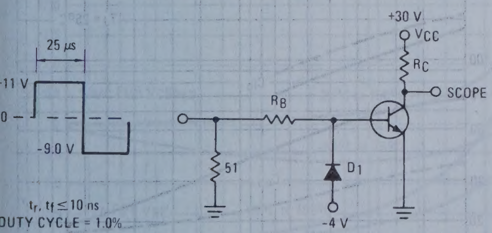
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	MJE220,MJE221,MJE222, MJE230,MJE231,MJE232	$V_{CEO(sus)}$	40	–	Vdc
	MJE223,MJE224,MJE225, MJE233,MJE234,MJE235		60	–	
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	MJE220,MJE221,MJE222, MJE230,MJE231,MJE232	I_{CBO}	–	0.1	μAdc
(V_{CB} = 80 Vdc, I_E = 0)	MJE223,MJE224,MJE225, MJE233,MJE234,MJE235		–	0.1	
(V_{CB} = 60 Vdc, I_E = 0, $T_C = 125^oC$)	MJE220,MJE221,MJE222, MJE230,MJE231,MJE232		–	0.1	mAdc
(V_{CB} = 80 Vdc, I_E = 0, $T_C = 125^oC$)	MJE223,MJE224,MJE225, MJE233,MJE234,MJE235		–	0.1	
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 1.0 Vdc)	MJE220,MJE230, MJE223,MJE233	h_{FE}	40	200	–
	MJE221,MJE231, MJE224,MJE234		40	150	
	MJE222,MJE232, MJE225,MJE235		25	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MJE221,MJE231, MJE224,MJE234		20	–	
	MJE222,MJE232, MJE225,MJE235		10	–	
(I_C = 2.0 Adc, V_{CE} = 1.0 Vdc)	MJE220,MJE230, MJE223,MJE233		20	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{CE(sat)}$	–	0.3	Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)	MJE221, MJE231, MJE224, MJE234		–	0.6	
(I_C = 2.0 Adc, I_B = 200 mAdc)	MJE220, MJE230, MJE223, MJE233		–	0.8	
(I_C = 4.0 Adc, I_B = 1.0 Adc)	All Types		–	2.5	
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)		$V_{BE(sat)}$	–	1.8	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	MJE220/MJE225	C_{ob}	–	50	pF
	MJE230/MJE235		–	70	

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE $I_B \approx 100$ mA
MSD6100 USED BELOW $I_B \approx 100$ mA

FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES

FIGURE 3 – TURN-ON TIME

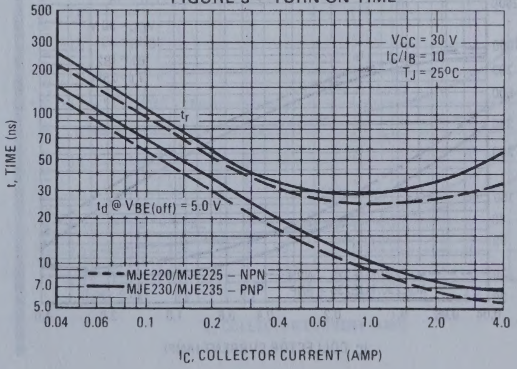


FIGURE 4 – THERMAL RESPONSE

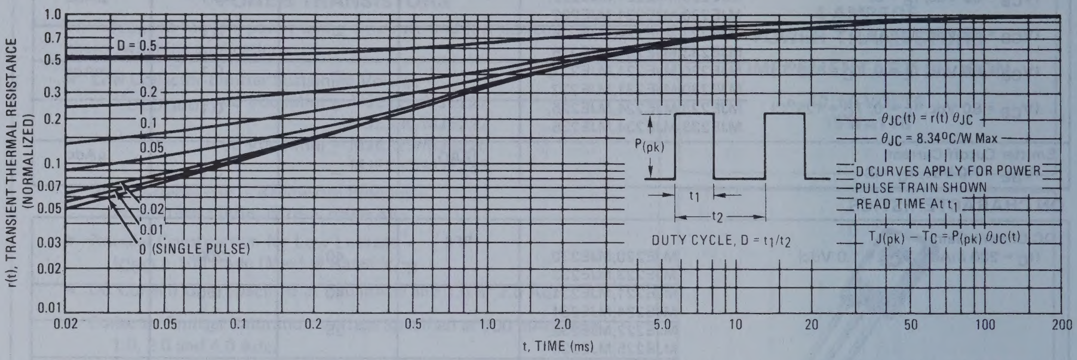
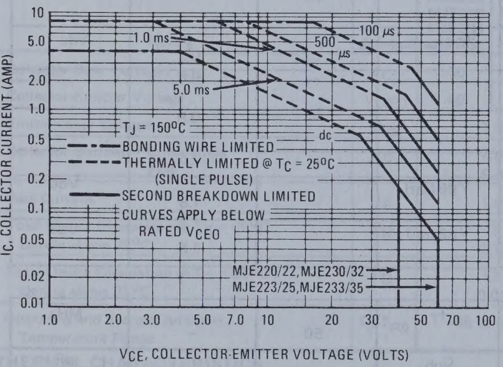


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

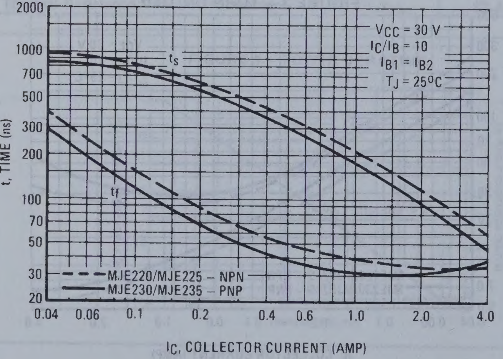
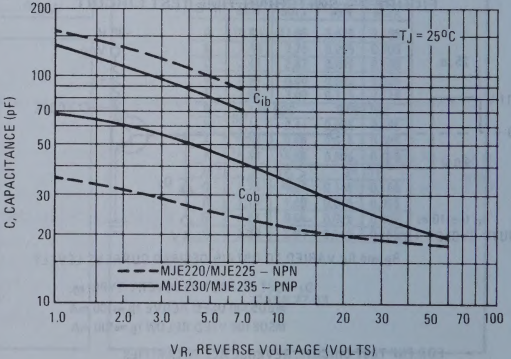


FIGURE 7 – CAPACITANCE



NPN
MJE220 thru MJE225

PNP
MJE230 thru MJE235

FIGURE 8 – DC CURRENT GAIN

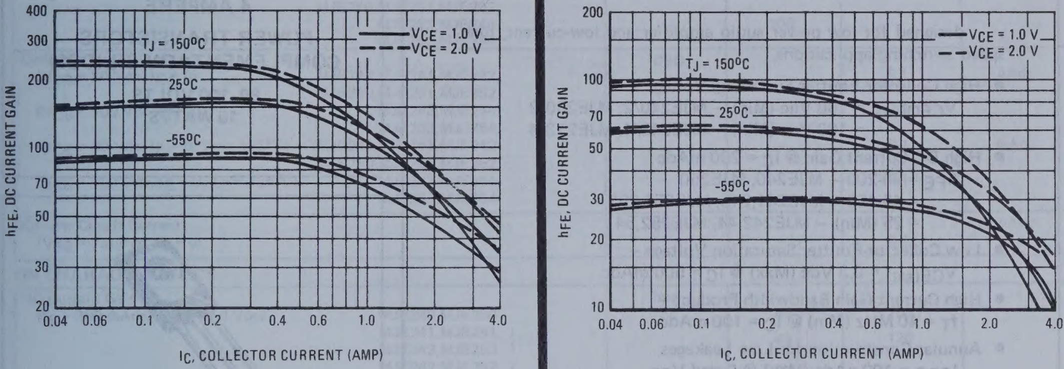


FIGURE 9 – "ON" VOLTAGES

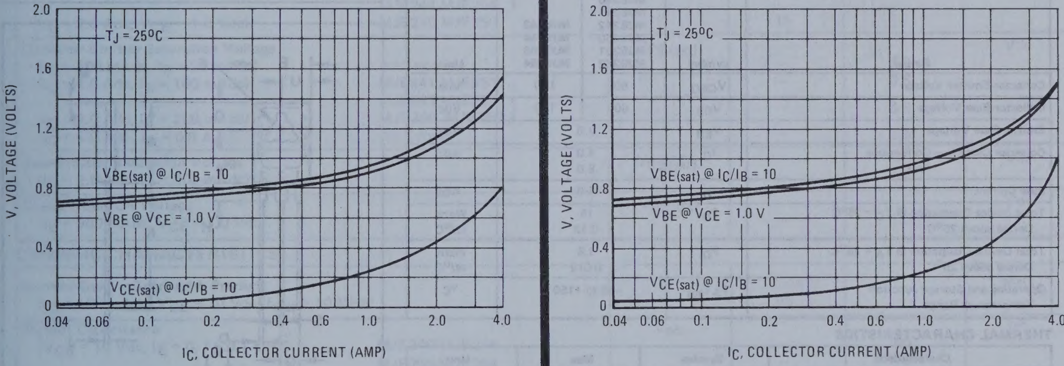
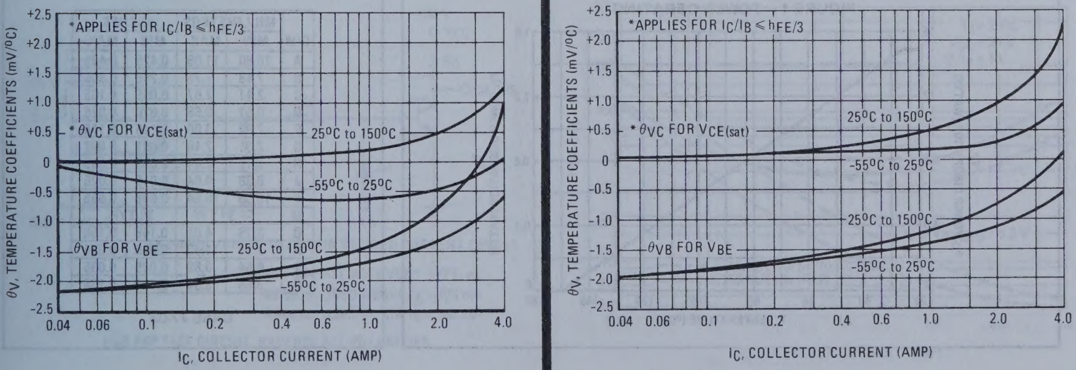


FIGURE 10 – TEMPERATURE COEFFICIENTS



MJE240 thru MJE244 NPN (SILICON)
MJE250 thru MJE254 PNP

COMPLEMENTARY SILICON POWER PLASTIC TRANSISTORS

. . . designed for low power audio amplifier and low-current, high-speed switching applications.

- High Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 80 Vdc (Min) — MJE240/2, MJE250/2
  = 100 Vdc (Min) — MJE243/4, MJE253/4
- High DC Current Gain @ I_C = 200 mAdc
  h_{FE} = 40-200 — MJE240, MJE250
  = 40-120 — MJE241,243, MJE251,253
  = 25 (Min) — MJE242,44, MJE252,54
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 500 mAdc
- High Current Gain Bandwidth Product —
  f_T = 40 MHz (Min) @ I_C = 100 mAdc
- Annular Construction for Low Leakages
  I_{CBO} = 100 nAdc (Max) @ Rated V_{CB}

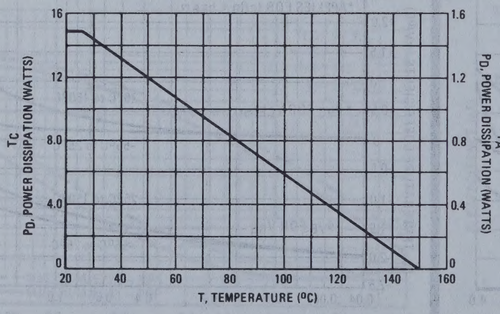
MAXIMUM RATINGS

Rating	Symbol	MJE240 MJE241 MJE242 MJE250 MJE251 MJE252	MJE243 MJE244 MJE253 MJE254	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 8.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12		Watts W/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.5 0.012		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

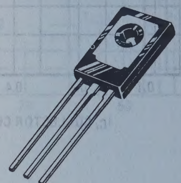
THERMAL CHARACTERISTICS

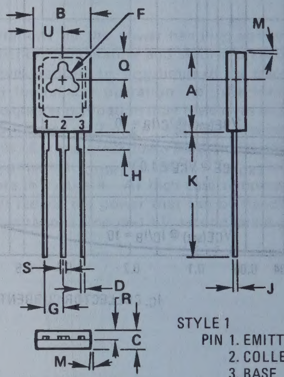
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.34	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	83.4	°C/W

FIGURE 1 — POWER DERATING



4 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
80, 100 VOLTS
15 WATTS





STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

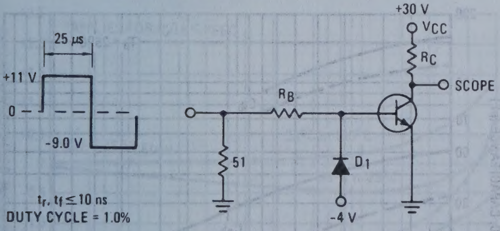
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0) MJE240,MJE241,MJE242, MJE250,MJE251,MJE252	$V_{CEO(sus)}$	80	–	Vdc
MJE243,MJE244 MJE253,MJE254		100	–	
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0) MJE240,MJE241,MJE242, MJE250,MJE251,MJE252	I_{CBO}	–	0.1	µAdc
(V_{CB} = 100 Vdc, I_E = 0) MJE243,MJE244, MJE253,MJE254,		–	0.1	
(V_{CE} = 80 Vdc, I_E = 0, T_C = 125°C) MJE240,MJE241,MJE242 MJE250,MJE251,MJE252,		–	0.1	mAdc
(V_{CE} = 100 Vdc, I_E = 0, T_C = 125°C) MJE243,MJE244 MJE253,MJE254		–	0.1	
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	µAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 200 mAdc, V_{CE} = 1.0 Vdc) MJE240,MJE250	h_{FE}	40	200	–
MJE241,MJE251, MJE243,MJE253		40	120	
MJE242,MJE252, MJE244,MJE254		25	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc) MJE241,MJE251, MJE243,MJE253		20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc) MJE242,MJE252 MJE244,MJE254		10	–	
(I_C = 2.0 Adc, V_{CE} = 1.0 Vdc) MJE240,MJE250		15	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) All Types	$V_{CE(sat)}$	–	0.3	Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc) MJE241,MJE251, MJE243,MJE253		–	0.6	
(I_C = 2.0 Adc, I_B = 200 mAdc) MJE240, MJE250		–	0.8	
(I_C = 4.0 Adc, I_B = 0.8 Adc) All Types		–	2.5	
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)	$V_{BE(sat)}$	–	1.8	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f_{test} = 10 MHz)	f_T	40	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz) MJE240/MJE244	C_{ob}	–	50	pF
MJE250/MJE254		–	70	

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D_1 MUST BE FAST RECOVERY TYPE, eg:
MBD5300 USED ABOVE I_B ≈100 mA
MSD6100 USED BELOW I_B ≈100 mA

FOR PNP TEST CIRCUIT, REVERSE ALL POLARITIES

FIGURE 3 – TURN-ON TIME

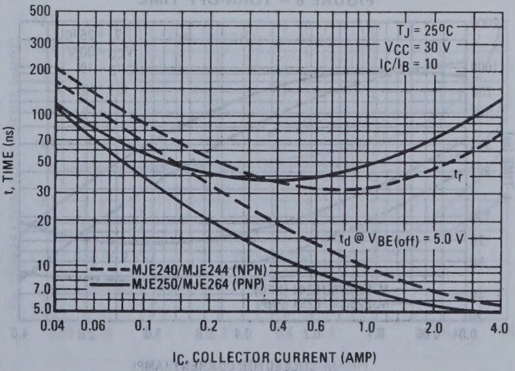


FIGURE 4 – THERMAL RESPONSE

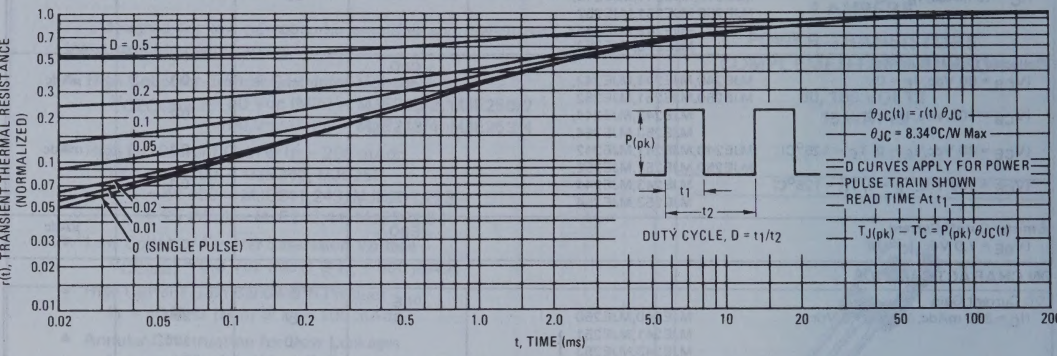
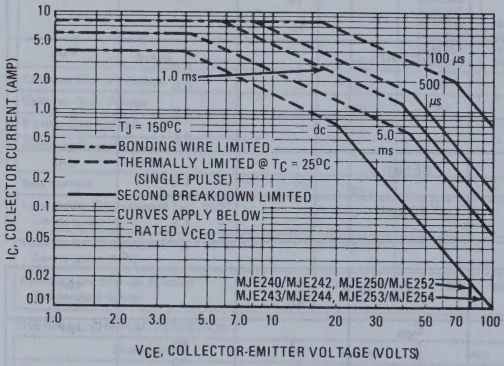


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

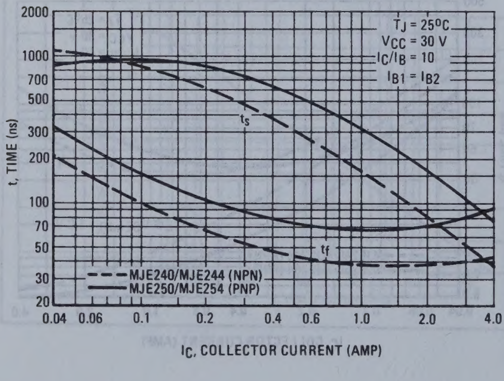
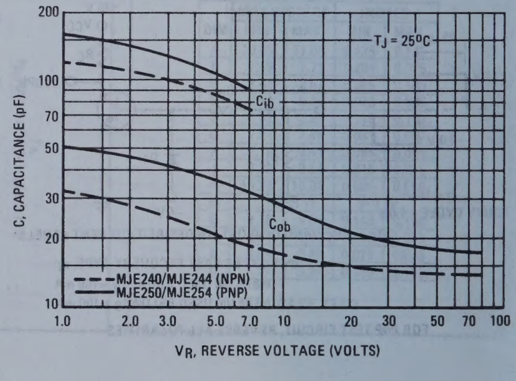


FIGURE 7 – CAPACITANCE



NPN
MJE240 thru MJE244

PNP
MJE250 thru MJE254

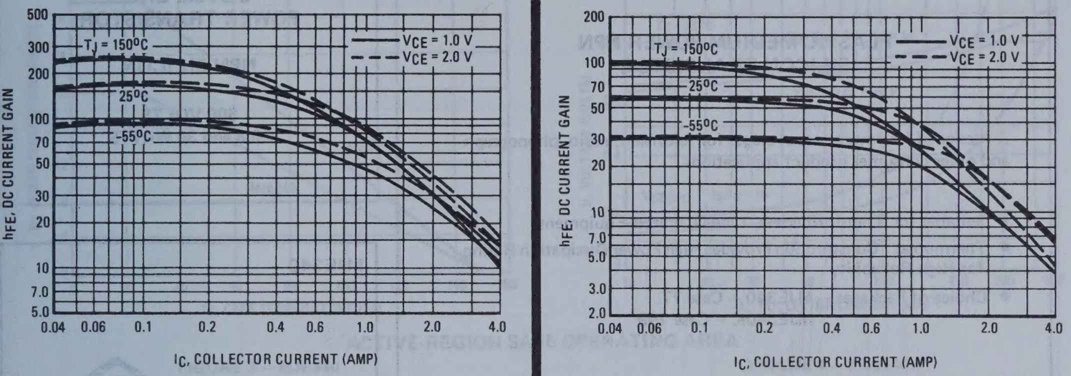


FIGURE 8 – DC CURRENT GAIN

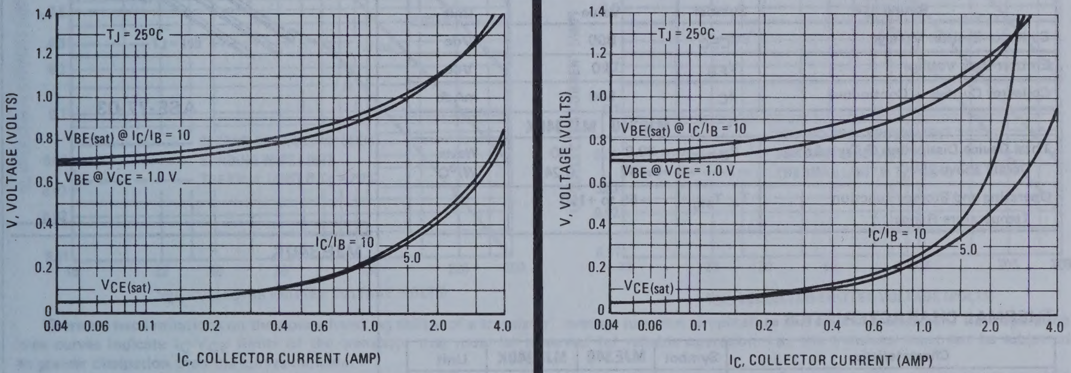


FIGURE 9 – "ON" VOLTAGES

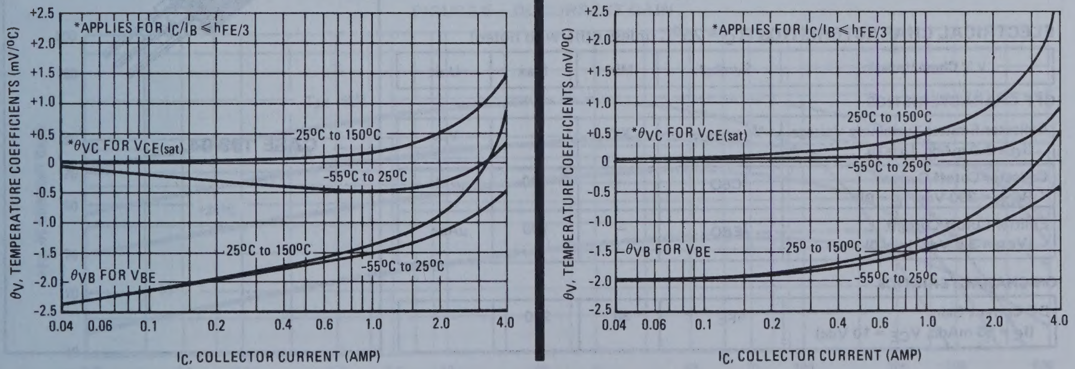


FIGURE 10 – TEMPERATURE COEFFICIENTS

MJE340 (SILICON)
MJE340K

PLASTIC MEDIUM POWER NPN SILICON TRANSISTOR

. . . designed for power output stages for television, radio, phonograph and other consumer product applications.

- Suitable for Transformerless, Line-Operated Equipment
- Thermopad Construction Provides High Power Dissipation Rating for High Reliability
- Choice of Packages – MJE340 – Case 77
  MJE340K – Case 199

0.5 AMPERE
POWER TRANSISTOR

NPN SILICON

300 VOLTS
20.8 and 30 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	300		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		MJE340	**MJE340K**	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20.8 0.167	30 0.24	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

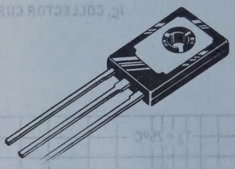
THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE340	MJE340K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	4.167	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

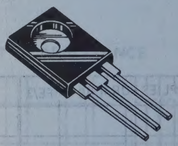
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	300	–	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	240	–

MJE340



ASE-77-03

MJE340K



CASE 199-04

FIGURE 1 – POWER TEMPERATURE DERATING

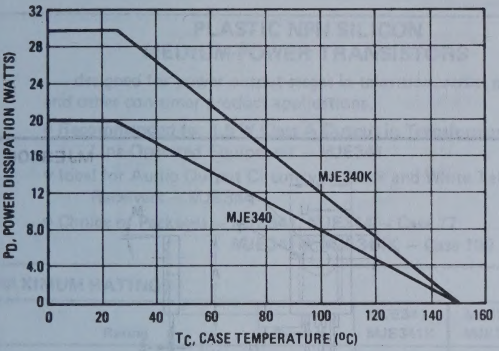
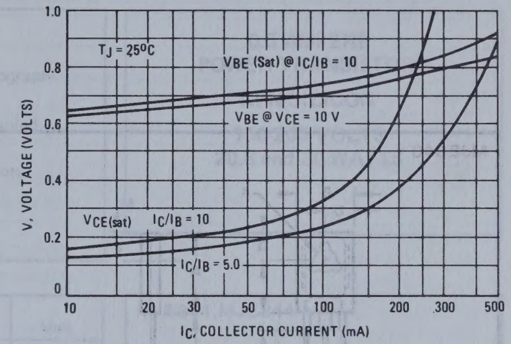


FIGURE 2 – "ON" VOLTAGES



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 3 – MJE340

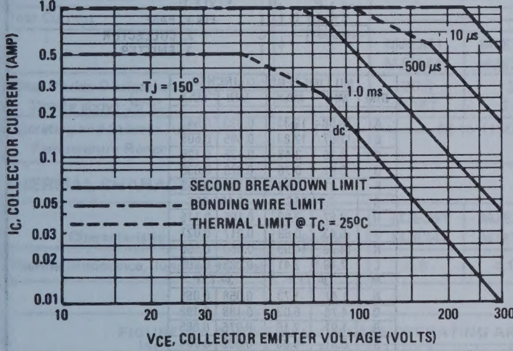
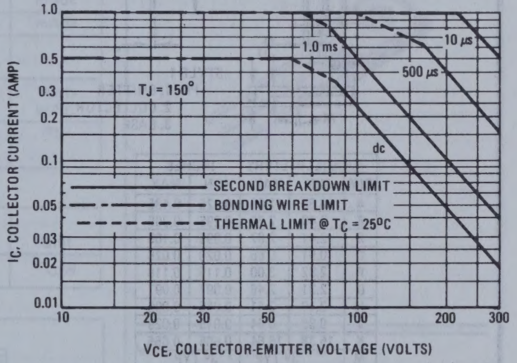


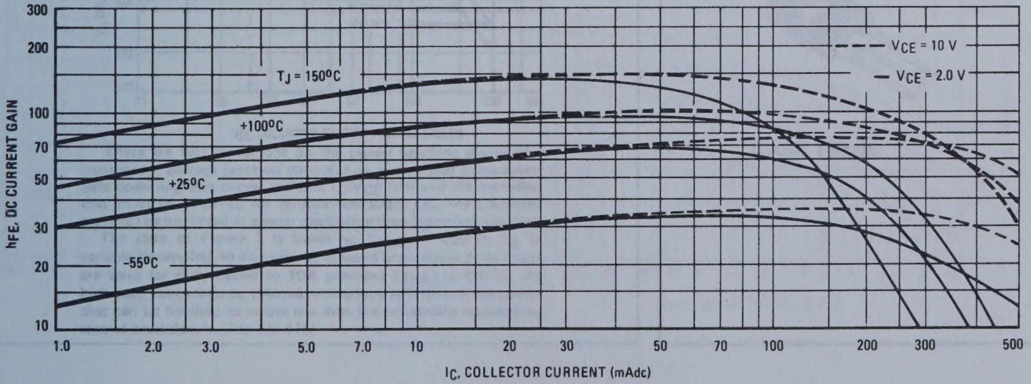
FIGURE 4 – MJE340K



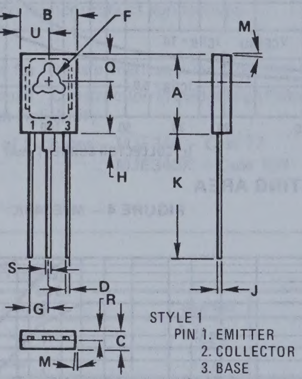
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 3 and 4 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 5 – DC CURRENT GAIN



MJE340

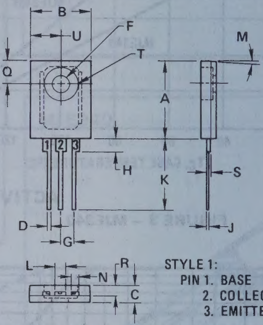


STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3⁰ TYP		3⁰ TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

MJE340K



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3⁰ TYP		3⁰ TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE341 MJE341K (SILICON)
MJE344 MJE344K

PLASTIC NPN SILICON MEDIUM-POWER TRANSISTORS

. . . designed for power output stages in television, radio, phonograph and other consumer product applications.

- Recommended for 1.5 W Class A Output in Transformer Coupled, Line-Operated Equipment — MJE341
- Ideal for Audio Output Circuitry in Black and White Television Receivers — MJE344
- Choice of Packages — MJE341, MJE344 — Case 77
  MJE341K, MJE344K — Case 199

0.5 AMPERE
POWER TRANSISTORS

NPN SILICON

150-200 VOLTS
20.8 and 30 WATTS

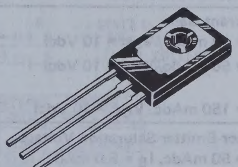
MAXIMUM RATINGS

Rating	Symbol	MJE341 MJE341K	MJE344 MJE344K	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	Vdc
Collector-Base Voltage	V_{CB}	175	200	Vdc
Emitter-Base Voltage	V_{EB}	3.0	5.0	Vdc
Collector Current — Continuous	I_C	←— 500 —→		mAdc
Base Current	I_B	←— 250 —→		mAdc
		MJE341 MJE344	MJE341K MJE344K	
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above 25°C	P_D	20.8 0.167	30 0.24	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	←— -65 to +150 —→		°C

THERMAL CHARACTERISTICS

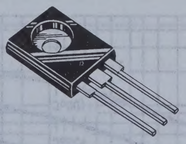
Characteristic	Symbol	MJE341 MJE344	MJE341K MJE344K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	4.167	°C/W

MJE341,MJE344



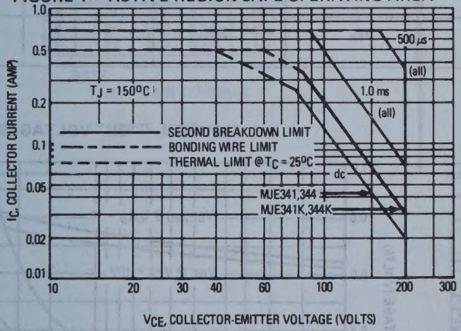
CASE 77-03

MJE341K, MJE344K



CASE 199-04

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)} = 150^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^{\circ}C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	MJE341,K MJE344,K	$V_{CEO(sus)}$	150 200	— —	Vdc
Collector Cutoff Current (V_{CE} = 150 Vdc, I_B = 0) (V_{CE} = 200 Vdc, I_B = 0)	MJE341,K MJE344,K	I_{CEO}	— —	1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = 175 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0)	MJE341,K MJE344,K	I_{CBO}	— —	0.3 0.1	mAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0) (V_{EB} = 5.0 Vdc, I_C = 0)	MJE341,K MJE344,K	I_{EBO}	— —	0.1 0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	 MJE341,K MJE341,K MJE344,K MJE341,K	h_{FE}	 20 25 30 20	 — 200 300 —	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	All Types MJE341,K	$V_{CE(sat)}$	— —	1.0 2.3	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 10 MHz)		f_T	15	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	15	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	—	—

FIGURE 2 – DC CURRENT GAIN

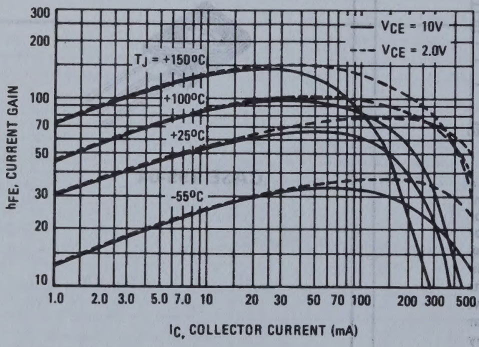
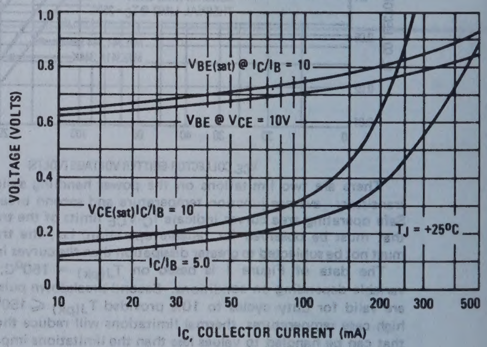
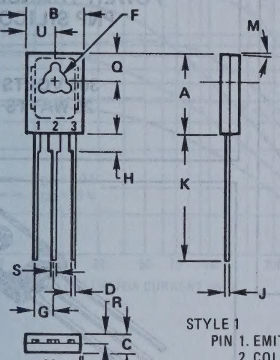


FIGURE 3 – "ON" VOLTAGES



MJE341, MJE344



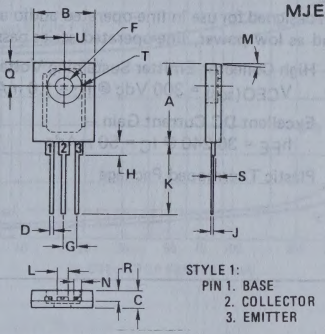
STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

NOTE:
1. MT = MAIN TERMINAL

CASE 77-03

MJE341K, MJE344K



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE350 (SILICON)

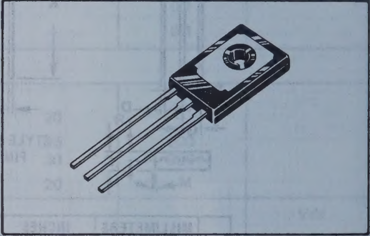
PLASTIC MEDIUM POWER PNP SILICON TRANSISTOR

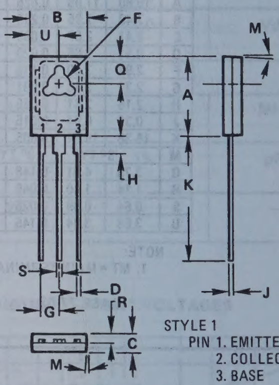
. . . designed for use in line-operated audio and television applications and as low power, line-operated series pass and switching regulators.

- High Collector-Emitter Sustaining Voltage — $V_{CEO(sus)} = 300$ Vdc @ $I_C = 1.0$ mAdc
- Excellent DC Current Gain — $h_{FE} = 30\text{-}240$ @ $I_C = 50$ mAdc
- Plastic Thermopad Package

0.5 AMPERE
POWER TRANSISTOR
PNP SILICON

300 VOLTS
20 WATTS





STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	20 0.16	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	$V_{CEO(sus)}$	300	—	Vdc
Collector Cutoff Current ($V_{CB} = 300$ Vdc, $I_E = 0$)	I_{CBO}	—	100	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	30	240	—

FIGURE 1 – DC CURRENT GAIN

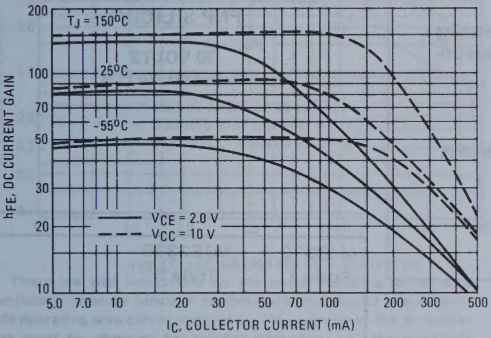


FIGURE 2 – "ON" VOLTAGES

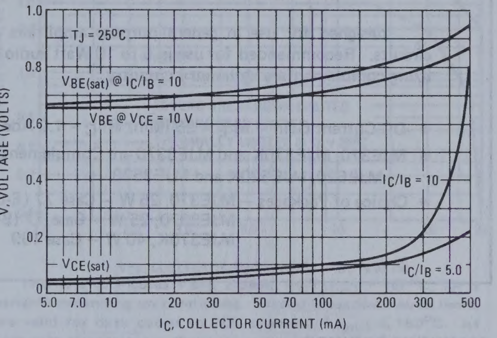


FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA

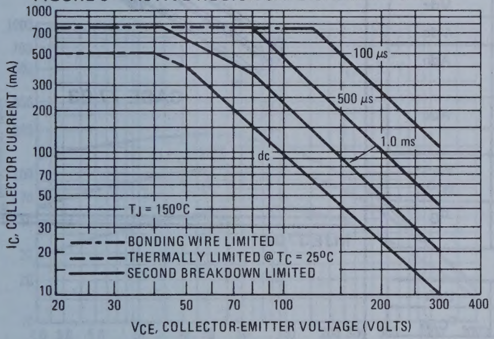
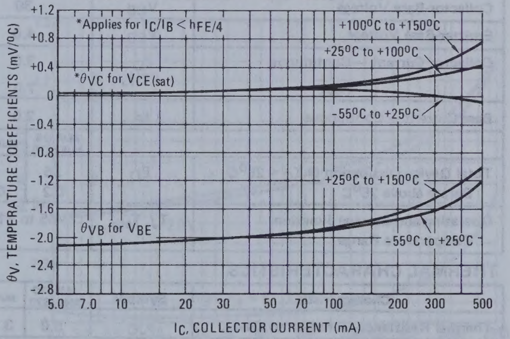


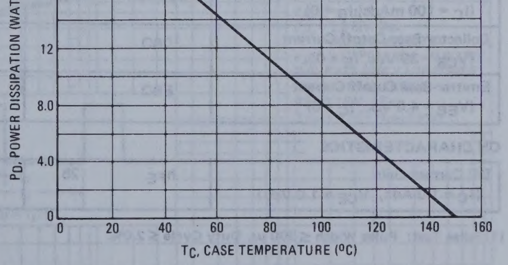
FIGURE 4 – TEMPERATURE COEFFICIENTS



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 5 – POWER DERATING



MJE370 (SILICON)
MJE370K
MJE3370

PLASTIC MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for use in general-purpose amplifiers and switching circuits. Recommended for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

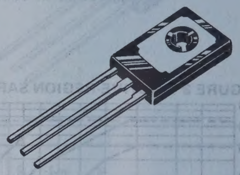
- DC Current Gain – h_{FE} = 25 (Min) @ I_C = 1.0 Adc
- MJE370, MJE370K and MJE3370 are Complementary with NPN MJE520, MJE520K and MJE3520
- Choice of Packages – MJE370, 25 W – Case 77 (E-C-B),
  MJE3370, 25 W – Case 77 (B-C-E)
  MJE370K, 40 W – Case 199

3 AMPERE
POWER TRANSISTORS

PNP SILICON

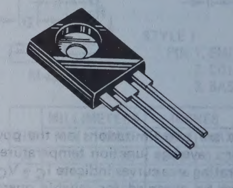
30 VOLTS
25 and 40 WATTS

MJE370 Style 1 MJE3370 Style 3



CASE 77-03

MJE370K



CASE 199-04

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	3.0		Adc
– Peak		7.0		
Base Current – Continuous	I_B	2.0		Adc
		MJE370 MJE3370	MJE370K	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.2	40 0.32	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE370 MJE3370	MJE370K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	3.125	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	25	–	–

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE370, MJE3370

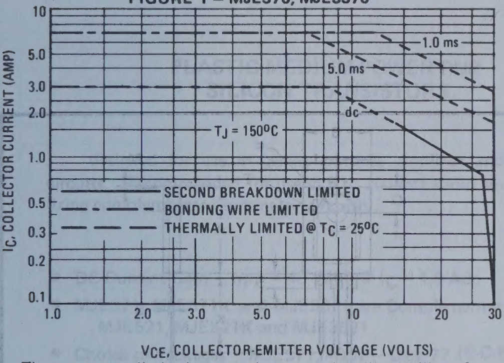
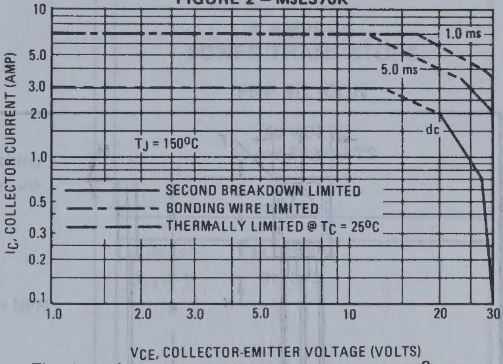


FIGURE 2 – MJE370K



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 1 and 2 based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J)pk)} \leqslant 150^{\circ}C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

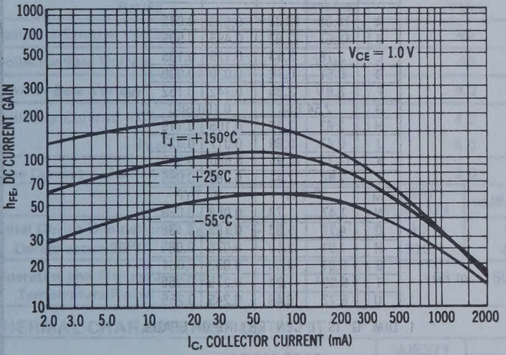


FIGURE 4 – "ON" VOLTAGE

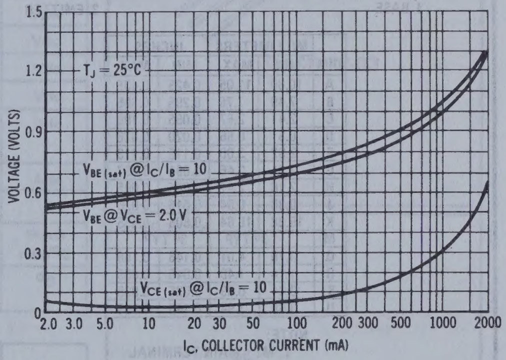
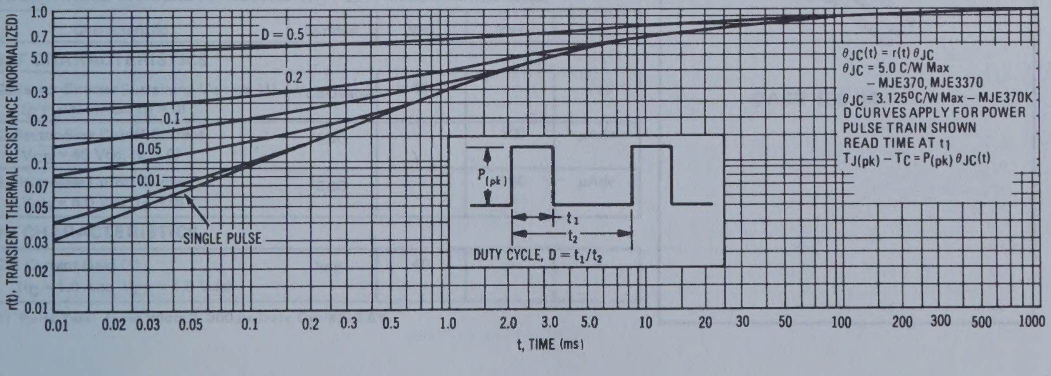
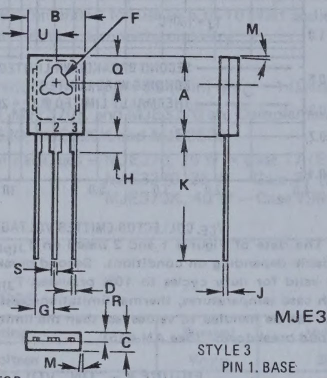


FIGURE 5 – THERMAL RESPONSE





MJE371

STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

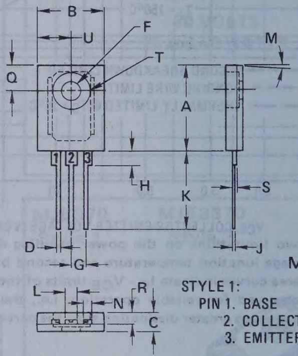
MJE3371

STYLE 3
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

NOTE:
1. MT = MAIN TERMINAL

CASE 77-03



MJE370K

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE371 (SILICON)
MJE371K
MJE3371

PLASTIC MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 20 Watt audio amplifiers utilizing complementary symmetry circuitry.

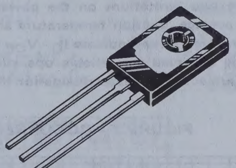
- DC Current Gain – h_{FE} = 40 (Min) @ I_C = 1.0 Adc
- MJE371, MJE371K and MJE3371 are Complementary with NPN MJE521, MJE521K and MJE3521
- Choice of Packages – MJE371, 40 W – Case 77 (E-C-B)
  MJE3371, 40 W – Case 77 R (B-C-E)
  MJE371K, 60 W – Case 199

4 AMPERE POWER TRANSISTORS

PNP SILICON

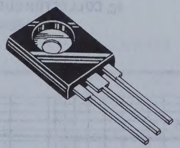
40 VOLTS
40 and 60 WATTS

MJE371 Style 1
MJE3371 Style 3



CASE 77-03

MJE371K



CASE 199-04

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	4.0		Adc
– Peak		8.0		
Base Current – Continuous	I_B	2.0		Adc
		MJE371 MJE3371	MJE371K	
Total Device Dissipation @ T_C = 25°C	P_D	40	60	Watts
Derate above 25°C		320	480	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE371 MJE3371	MJE371K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	2.08	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	µAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	µAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	40	–	–

(1) Pulse Test: Pulse Width ≤ 300 µs Duty Cycle ≤ 2.0%.

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE371, MJE3371

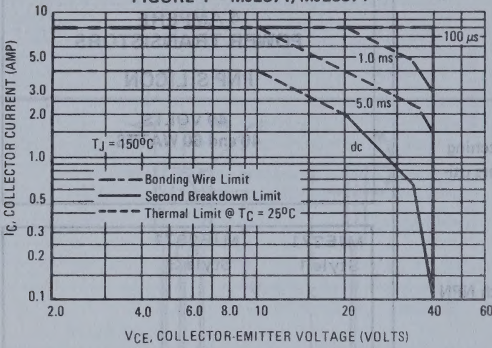
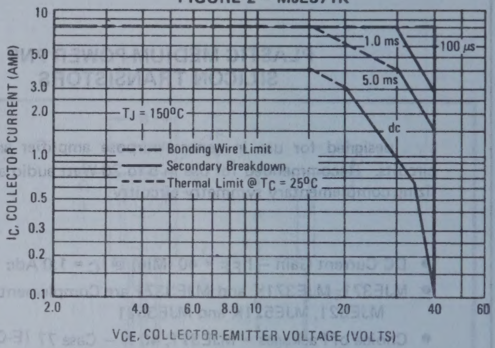


FIGURE 2 – MJE371K



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 1 and 2 based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J)pk)} \leq 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

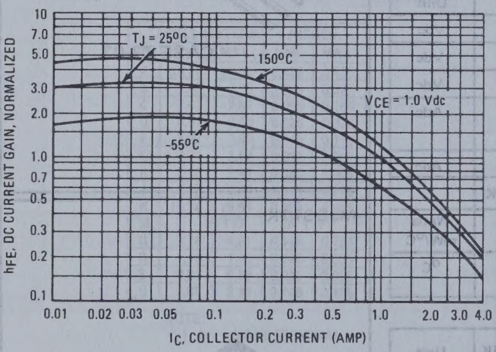


FIGURE 4 – "ON" VOLTAGE

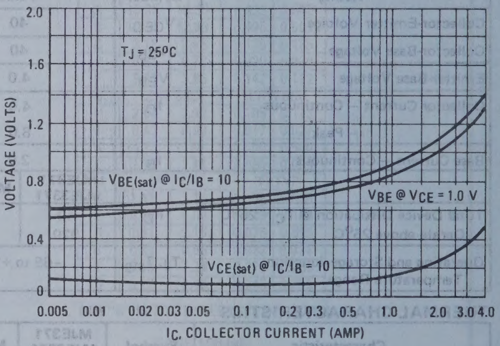
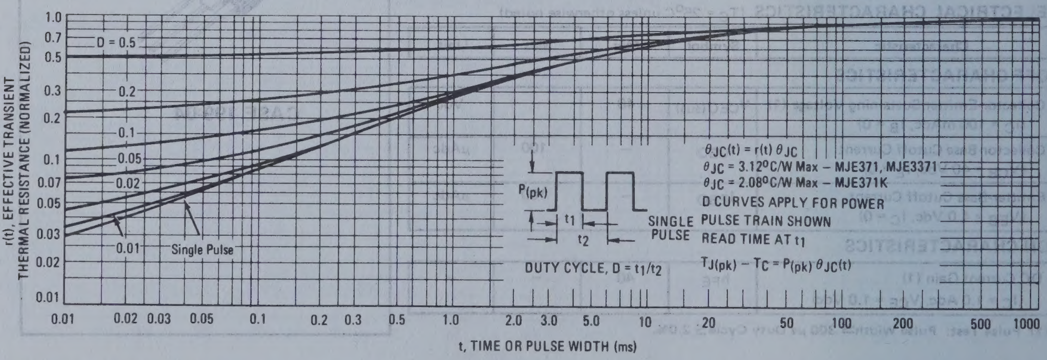
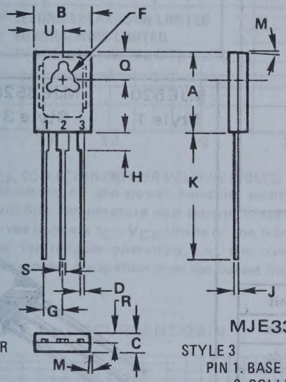


FIGURE 5 – THERMAL RESPONSE



$\theta_{JC}(t) = r(t)\ \theta_{JC}$
$\theta_{JC} = 3.12^oC/W$ Max – MJE371, MJE3371
$\theta_{JC} = 2.08^oC/W$ Max – MJE371K
D CURVES APPLY FOR POWER PULSE TRAIN SHOWN
READ TIME AT t_1
$T_{J(pk)} - T_C = P_{(pk)}\ \theta_{JC}(t)$



MJE371

STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

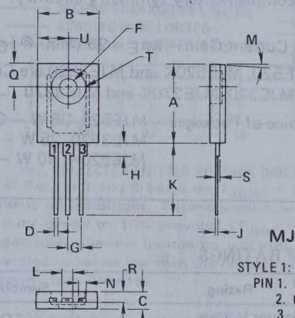
MJE3371

STYLE 3
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

NOTE:
1. MT = MAIN TERMINAL

CASE 77-03



MJE371K

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE520 (SILICON)
MJE520K
MJE3520

PLASTIC MEDIUM-POWER NPN SILICON TRANSISTORS

. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain — h_{FE} = 25 (Min) @ I_C = 1.0 Adc
- MJE520, MJE520K and MJE3520 are Complementary with PNP MJE370, MJE370K and MJE3370
- Choice of Packages — MJE520, 25 W — Case 77 (E-C-B)
  MJE3520, 25 W — Case 77 (B-C-E)
  MJE520K, 40 W — Case 199

3 AMPERE
POWER TRANSISTORS

NPN SILICON

30 VOLTS
25 and 40 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	3.0		Adc
— Peak		7.0		
Base Current — Continuous	I_B	2.0		Adc
		MJE520 MJE3520	MJE520K	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.2	40 0.32	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE520 MJE3520	MJE520K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	3.125	°C/W

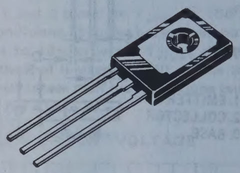
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	25	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

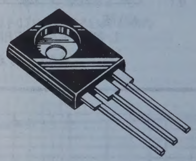
MJE520
Style 1

MJE3520
Style 3



CASE 77-03

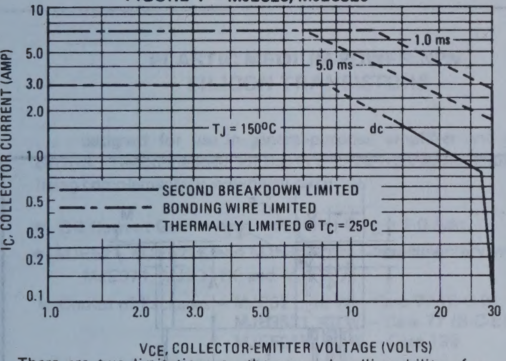
MJE520K



CASE 199-04

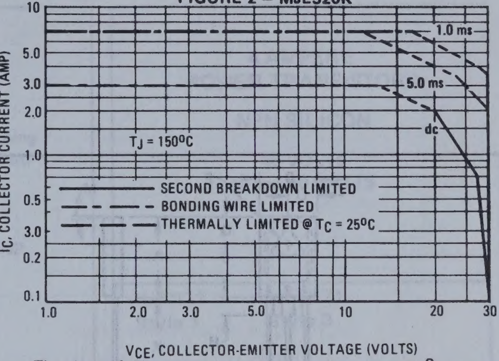
ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE520, MJE3520



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

FIGURE 2 – MJE520K



The data of Figures 1 and 2 based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $(T_{Jpk}) \leqslant 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

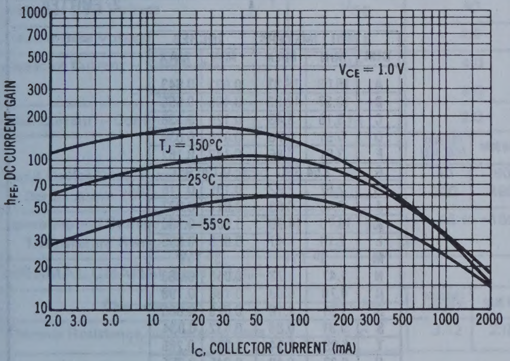


FIGURE 4 – "ON" VOLTAGE

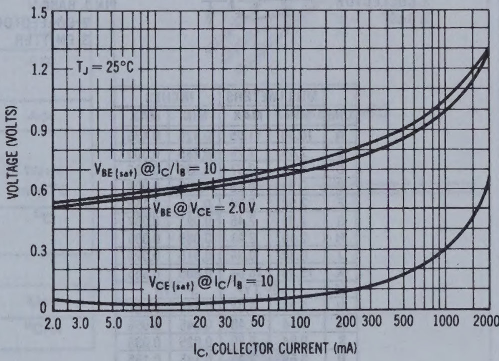
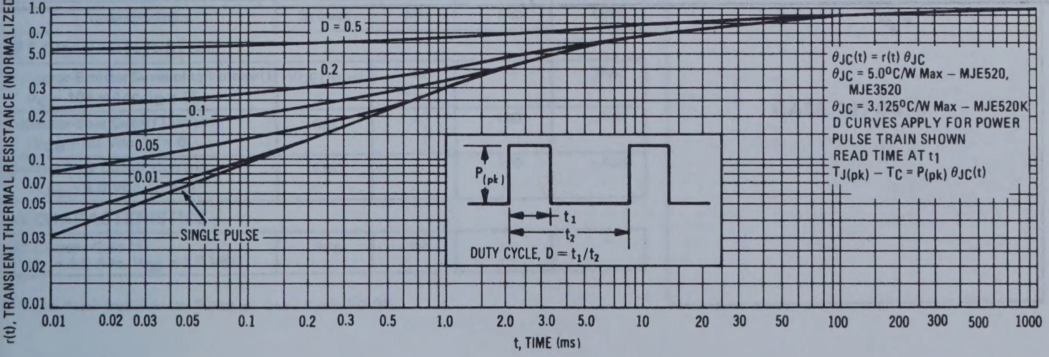
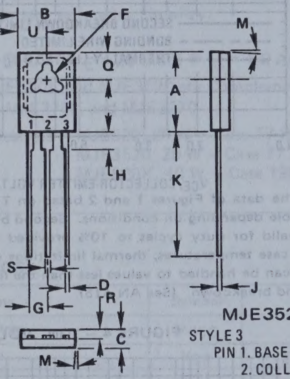


FIGURE 5 – THERMAL RESPONSE





MJE520

STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

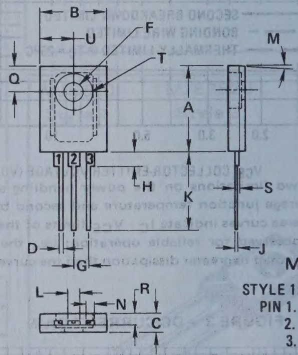
MJE3520

STYLE 3
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

NOTE:
1. MT = MAIN TERMINAL

CASE 77-03



MJE520K

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE521 (SILICON)
MJE521K
MJE3521

PLASTIC MEDIUM-POWER NPN SILICON TRANSISTORS

. . . designed for use in general-purpose amplifier and switching circuits. Recommended for use in 5 to 20 Watt audio amplifiers utilizing complementary symmetry circuitry.

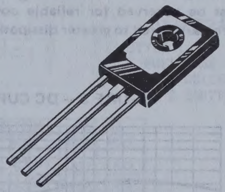
- DC Current Gain – h_{FE} = 40 (Min) @ I_C = 1.0 Adc
- MJE521, MJE521K and MJE3521 are Complementary with PNP MJE371, MJE371K and MJE3371
- Choice of Packages – MJE521, 40 W – Case 77 (E-C-B)
  MJE3521, 40 W – Case 77 (B-C-E)
  MJE521K, 60 W – Case 199

4 AMPERE
POWER TRANSISTORS

NPN SILICON

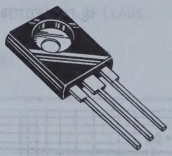
40 VOLTS
40 and 60 WATTS

MJE521 Style 1 MJE3521 Style 3



CASE 77-03

MJE521K



CASE 199-04

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	4.0		Adc
– Peak		8.0		
Base Current – Continuous	I_B	2.0		Adc
		MJE521 MJE3521	MJE521K	
Total Device Dissipation @ T_C = 25°C	P_D	40	60	Watts
Derate above 25°C		320	480	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJE521 MJE3521	MJE521K	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	2.08	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	µAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	µAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	40	–	–

(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MJE521, MJE3521

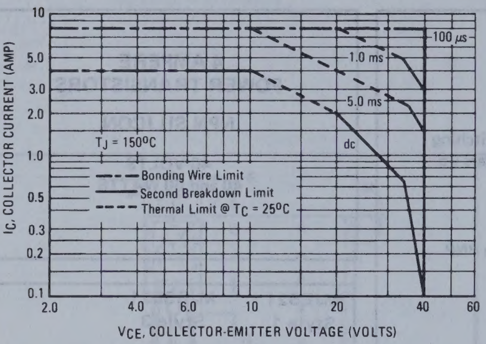
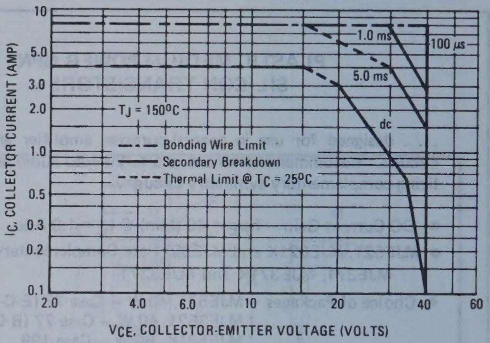


FIGURE 2 – MJE521K



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 1 and 2 based on $T_{J(pk)} = 150^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J)pk)} \leq 150^\circ C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 – DC CURRENT GAIN

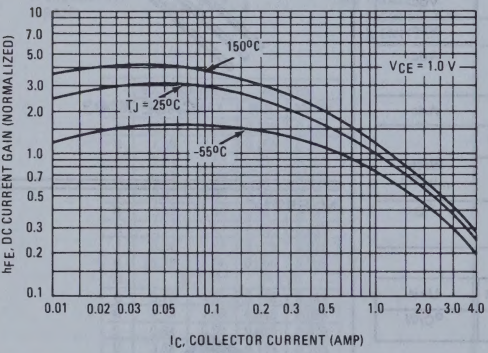


FIGURE 4 – "ON" VOLTAGE

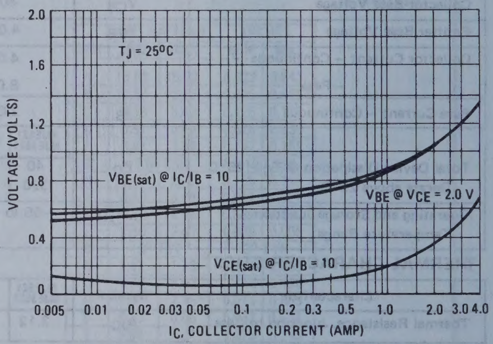
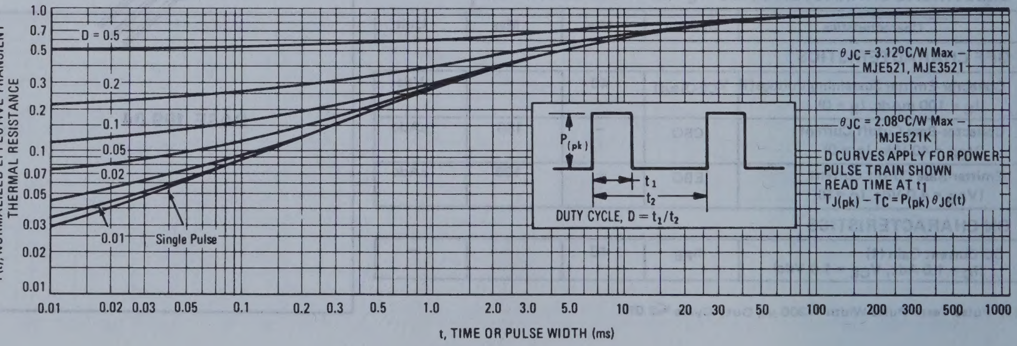
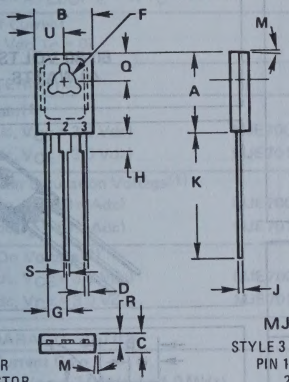


FIGURE 5 – THERMAL RESPONSE





MJE521

STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

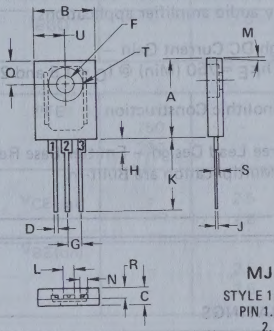
MJE3521

STYLE 3
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

NOTE:
1. MT = MAIN TERMINAL

CASE 77-03



MJE521K

STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE700 thru MJE703 PNP (SILICON)
MJE800 thru MJE803 NPN

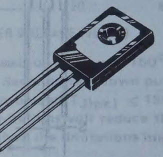
PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . designed to replace discrete driver and output stages in complementary audio amplifier applications.

- High DC Current Gain —
  h_{FE} = 750 (Min) @ I_C = 1.5 and 2.0 Adc
- Monolithic Construction
- Three Lead Design — Emitter-Base Resistors to Prevent Leakage Multiplication are Built-In.

4.0 AMPERE
DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON

60-80 VOLTS
40 WATTS

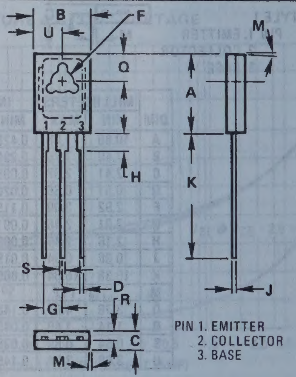


MAXIMUM RATINGS

Rating	Symbol	MJE700 MJE701 MJE800 MJE801	MJE702 MJE703 MJE802 MJE803	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	4.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	40 0.32		Watts $W/^oC$
Operating and Storage Junction Temperating Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.13	$^oC/W$



PIN 1. EMITTER
2. COLLECTOR
3. BASE

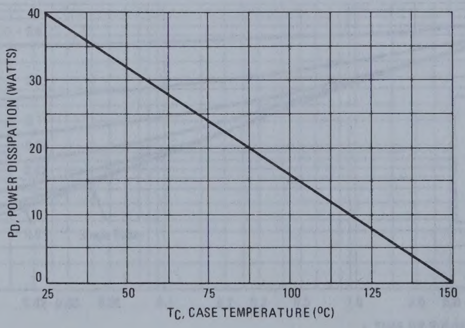
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

FIGURE 1 — POWER DERATING

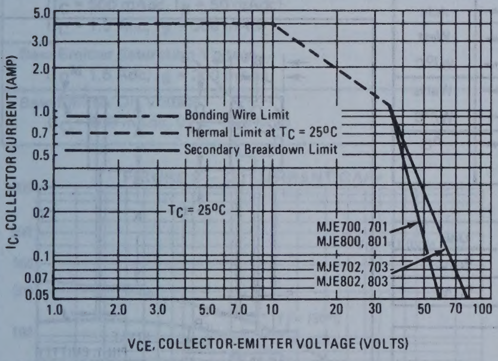


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage[1] (I_C = 50 mAdc, I_B = 0) MJE700, MJE701, MJE800, MJE801 MJE702, MJE703, MJE802, MJE803	BV_{CEO}	 60 80	 – –	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0) MJE700, MJE701, MJE800, MJE801 (V_{CE} = 40 Vdc, I_B = 0) MJE702, MJE703, MJE802, MJE803	I_{CEO}	 – –	 500 500	μAdc
Collector Cutoff Current (V_{CB} = Rated BV_{CEO}, I_E = 0) (V_{CB} = Rated BV_{CEO}, I_E = 0, T_C = 100°C)	I_{CBO}	 – –	 0.2 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain[1] (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc) MJE700, MJE702, MJE800, MJE802 (I_C = 2.0 Adc, V_{CE} = 3.0 Vdc) MJE701, MJE703, MJE801, MJE803	h_{FE}	 750 750	 – –	–
Collector-Emitter Saturation Voltage[1] (I_C = 1.5 Adc, I_B = 30 mAdc) MJE700, MJE702, MJE800, MJE802 (I_C = 2.0 Adc, I_B = 40 mAdc) MJE701, MJE703, MJE801, MJE803	$V_{CE(sat)}$	 – –	 2.5 2.8	Vdc
Base-Emitter On Voltage[1] (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc) MJE700, MJE702, MJE800, MJE802 (I_C = 2.0 Adc, V_{CE} = 3.0 Vdc) MJE701, MJE703, MJE801, MJE803	$V_{BE(on)}$	 – –	 2.5 2.5	Vdc
DYNAMIC CHARACTERISTICS				
Small-Signal Current Gain (I_C = 1.5 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)	h_{fe}	1.0	–	–

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

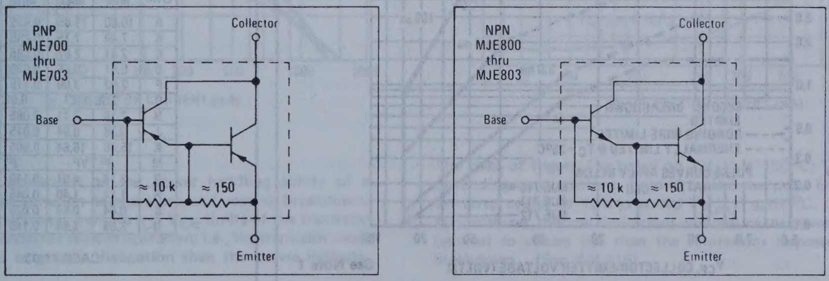
FIGURE 2 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC



MJE710 (SILICON)
MJE711
MJE712

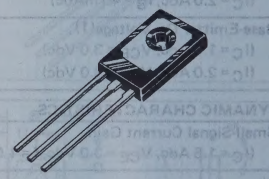
PNP SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in low power amplifiers, as drivers in high-power amplifier and medium-speed switching circuits.

- DC Current Gain —
  h_{FE} = 40 (Min) @ I_C = 150 mAdc
  = 20 (Min) @ I_C = 500 mAdc
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 40, 60, 80 Vdc (Min) @ I_C = 50 mAdc
- Complement to NPN Types MJE720, MJE721, MJE722 Series
- Equivalent to the Specifications of the Pro-Electron BD166, BD168 and BD170 Transistors

1.5 AMPERE
POWER TRANSISTORS
PNP SILICON

40, 60, 80 VOLTS
20 WATTS



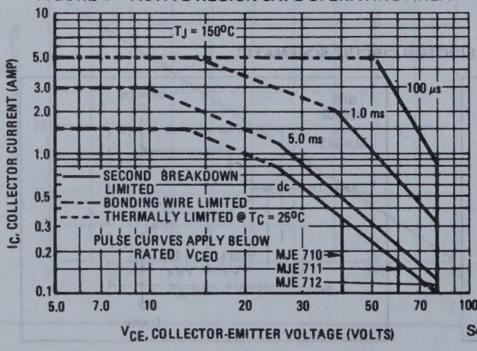
MAXIMUM RATINGS

Rating	Symbol	MJE 710	MJE 711	MJE 712	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	1.5			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.25 0.008			Watt W/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20 0.16			Watts W/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			^oC

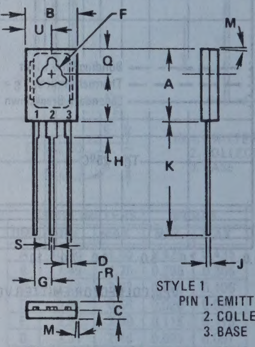
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	$^oC/W$
Thermal Resistance, Junction to Ambient	θ_{JA}	100	$^oC/W$

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



See Note 1



STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3^0 TYP		3^0 TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	MJE710		40	–	
	MJE711		60	–	
	MJE712		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 20 Vdc, I_B = 0)	MJE710		–	500	
(V_{CE} = 30 Vdc, I_B = 0)	MJE711		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE712		–	500	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE710		–	100	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE711		–	100	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE712		–	100	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, $T_C = 125^oC$)	MJE710		–	500	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, $T_C = 125^oC$)	MJE711		–	500	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, $T_C = 125^oC$)	MJE712		–	500	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			8.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.15	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.4	
(I_C = 1.5 Adc, I_B = 300 mAdc			–	1.0	
Base-Emitter Saturation Voltage (I_C = 1.5 Adc, I_B = 300 mAdc)		$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	0.95	Vdc

FIGURE 2 – DC CURRENT GAIN

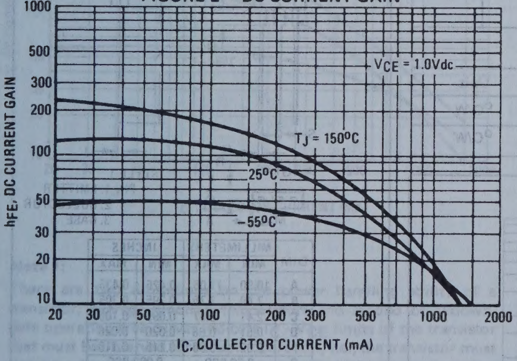
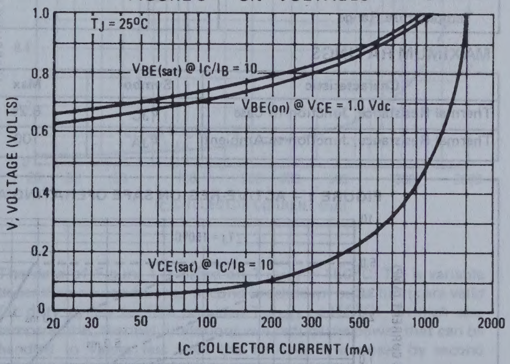


FIGURE 3 – "ON" VOLTAGES



Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJE720 (SILICON)
MJE721
MJE722

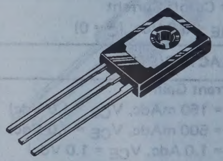
NPN SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in low-power amplifiers, as drivers in high-power amplifier and medium-speed switching circuits.

- DC Current Gain —
  h_{FE} = 40 (Min) @ I_C = 150 mAdc
  = 20 (Min) @ I_C = 500 mAdc
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 40, 60, 80 Vdc (Min) @ I_C = 50 mAdc
- Complement to PNP Types MJE710, MJE711, MJE712 Series
- Equivalent to the Specifications of the Pro-Electron BD165, BD167, and BD169 Transistors

1.5 AMPERE
POWER TRANSISTORS
NPN SILICON

40, 60, 80 VOLTS
20 WATTS



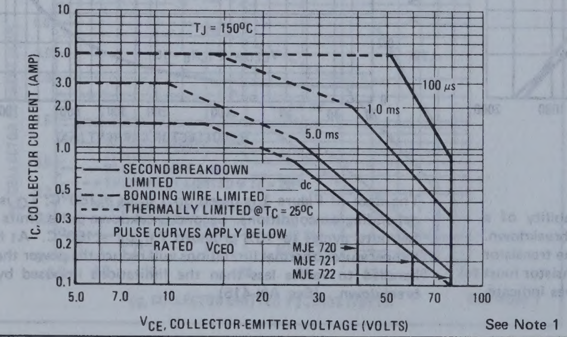
THERMAL CHARACTERISTICS

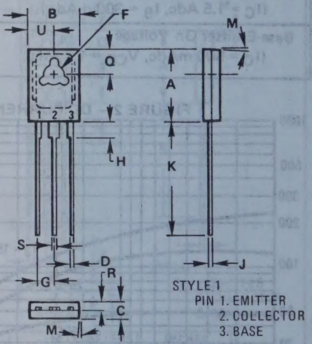
Rating	Symbol	MJE720	MJE721	MJE722	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}		5.0		Vdc
Collector Current — Continuous	I_C	← 1.5 →			Adc
Base Current	I_B	← 0.5 →			Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	← 1.25 → ← 0.008 →			Watt W/°C
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	← 20 → ← 0.16 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →			°C

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	100	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, I_B = 0)	MJE720 MJE721 MJE722	$V_{CEO(sus)}$	40 60 80	– – –	Vdc
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 20 Vdc, I_B = 0)	MJE720		–	500	
(V_{CE} = 30 Vdc, I_B = 0)	MJE721		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE722		–	500	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE720		–	100	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE721		–	100	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJE722		–	100	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE720		–	500	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE721		–	500	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	MJE722		–	500	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			8.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.15	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.4	
(I_C = 1.5 Adc, I_B = 300 mAdc			–	1.0	
Base-Emitter Saturation Voltage (I_C = 1.5 Adc, I_B = 300 mAdc		$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	0.95	Vdc

FIGURE 2 – DC CURRENT GAIN

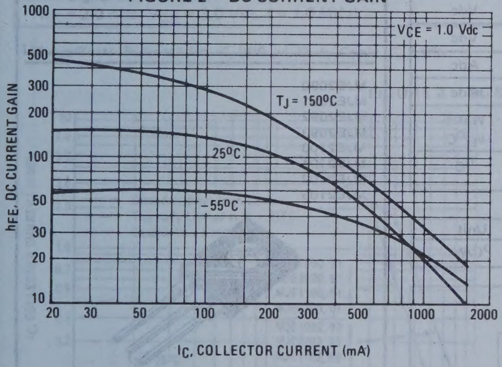
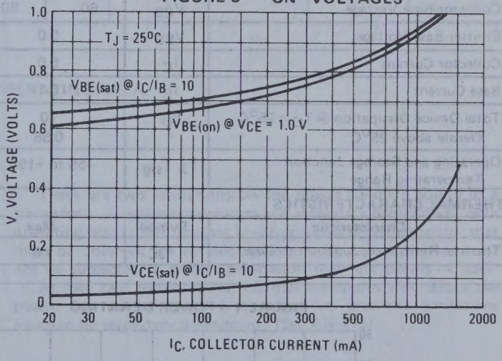


FIGURE 3 – "ON" VOLTAGES



Note 1:

There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150$°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

MJE800 thru MJE803 (SILICON)

For Specifications, See MJE700 Data.

MJE1090 thru MJE1093 PNP (SILICON)
MJE2090 thru MJE2093
MJE1100 thru MJE1103 NPN
MJE2100 thru MJE2103

PLASTIC MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

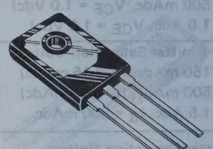
Designed for use in driver and output stages in complementary audio amplifier applications.

- High DC Current Gain — h_{FE} = 750 (Min) @ I_C = 3.0 and 4.0 Adc
- True Three Lead Monolithic Construction — Emitter-Base Resistors to Prevent Leakage Multiplication are Built in.
- Available in Two Packages — Case 90 or Case 199

5.0 AMPERE
DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON

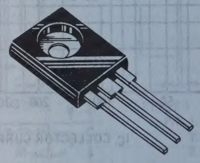
60-80 VOLTS
70 WATTS

MJE1090
MJE1091
MJE1092
MJE1093
MJE1100
MJE1101
MJE1102
MJE1103



CASE 90-05

MJE2090
MJE2091
MJE2092
MJE2093
MJE2100
MJE2101
MJE2102
MJE2103



CASE 199-04

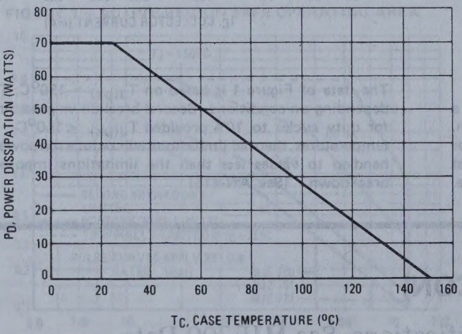
MAXIMUM RATINGS

Rating	Symbol	MJE1090 MJE1091 MJE1100 MJE1101 MJE2090 MJE2091 MJE2100 MJE2101	MJE1092 MJE1093 MJE1102 MJE1103 MJE2092 MJE2093 MJE2102 MJE2103	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	5.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 0.56		Watts W/°C
Operating and Storage Junction Temperating Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.8	°C/W

FIGURE 1 – POWER DERATING



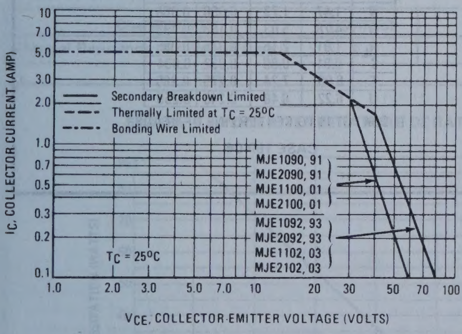
MJE1090 thru MJE1093 PNP/MJE1100 thru MJE1103 NPN (continued)
MJE2090 thru MJE2093 PNP/MJE2100 thru MJE2103 NPN

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage[1]		BV_{CEO}			Vdc
(I_C = 100 mAdc, I_B = 0)	MJE1090, MJE1091, MJE1100, MJE1101		60	–	
	MJE2090, MJE2091, MJE2100, MJE2101		60	–	
	MJE1092, MJE1093, MJE1102, MJE1103		80	–	
	MJE2092, MJE2093, MJE2102, MJE2103		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJE1090, MJE1091, MJE1100, MJE1101		–	500	
	MJE2090, MJE2091, MJE2100, MJE2101		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE1092, MJE1093, MJE1102, MJE1103		–	500	
	MJE2092, MJE2093, MJE2102, MJE2103		–	500	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = Rated BV_{CEO}, I_E = 0)			–	0.2	
(V_{CB} = Rated BV_{CEO}, I_E = 0, T_C = 100°C)			–	2.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102		750	–	
	MJE2090, MJE2092, MJE2100, MJE2102		750	–	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJE1091, MJE1093, MJE1101, MJE1103		750	–	
	MJE2091, MJE2093, MJE2101, MJE2103		750	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 12 mAdc)	MJE1090, MJE1092, MJE1100, MJE1102		–	2.5	
	MJE2090, MJE2092, MJE2100, MJE2102		–	2.5	
(I_C = 4.0 Adc, I_B = 16 mAdc)	MJE1091, MJE1093, MJE1101, MJE1103		–	2.8	
	MJE2091, MJE2093, MJE2101, MJE2103		–	2.8	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102		–	2.5	
	MJE2090, MJE2092, MJE2100, MJE2102		–	2.5	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJE1091, MJE1093, MJE1101, MJE1103		–	2.5	
	MJE2091, MJE2093, MJE2101, MJE2103		–	2.5	
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		h_{fe}	1.0	–	–

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

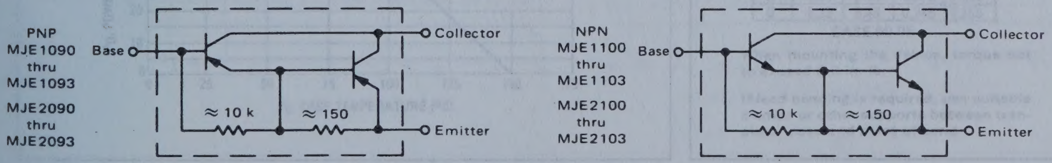
FIGURE 2 – DC SAFE OPERATING AREA



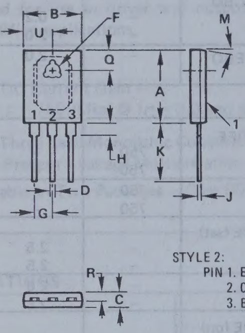
There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C – V_{CE} limits of the transistor that must be observed for reliable operation; e.g., the transistor must not be subjected to greater dissipation than the curves indicate.

At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC



MJE1090
MJE1091
MJE1092
MJE1093
MJE1100
MJE1101
MJE1102
MJE1103



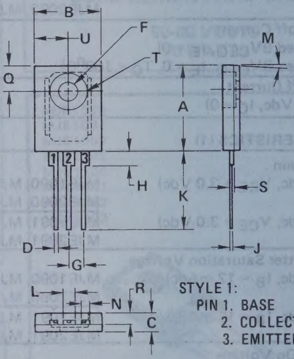
STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

CASE 90-05

MJE2090
MJE2091
MJE2092
MJE2093
MJE2100
MJE2101
MJE2102
MJE2103



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE1290, MJE1291 PNP (SILICON)
MJE1660, MJE1661 NPN

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in power amplifier and switching applications.

- High Collector Current — $I_C = 15$ Adc
- High DC Current Gain — $h_{FE} = 10$ (Min) @ $I_C = 15$ Adc

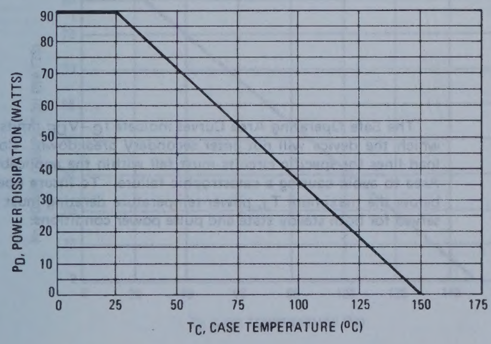
MAXIMUM RATINGS

Rating	Symbol	MJE1290 MJE1660	MJE1291 MJE1661	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current-Continuous	I_C	15		Adc
Base Current	I_B	5.0		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	90 0.72		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		^oC

THERMAL CHARACTERISTICS

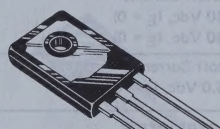
Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	$^oC/W$

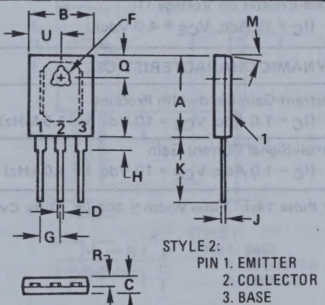
FIGURE 1 – POWER TEMPERATURE DERATING CURVE



15 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

40-60 VOLTS
90 WATTS





STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

CASE 90-05

When mounting the device, torque not to exceed 8.0 in.-lb.

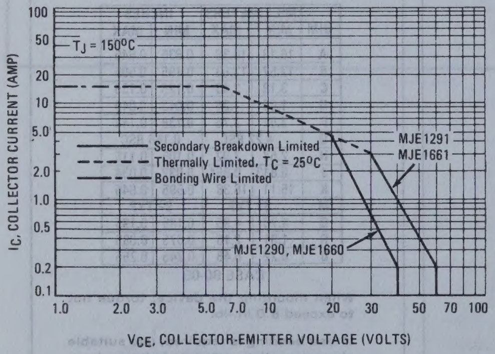
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	MJE1290, MJE1660 MJE1291, MJE1661	$V_{CEO(sus)}$	40 60	– –	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)		I_{CEO}	–	1.0	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0) (V_{CE} = 60 Vdc, V_{BE} = 0)	MJE1290, MJE1660 MJE1291, MJE1661	I_{CES}	– –	0.7 0.7	mAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	MJE1290, MJE1660 MJE1291, MJE1661	I_{CBO}	– –	0.7 0.7	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_E = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 5.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 15 Adc, V_{CE} = 4.0 Vdc)		h_{FE}	20 10	100 –	–
Collector-Emitter Saturation Voltage (1) (I_C = 15 Adc, I_B = 1.5 Adc)		$V_{CE(sat)}$	–	1.8	Vdc
Base-Emitter on Voltage (1) (I_C = 15 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	2.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	–	MHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

(1) Pulse Test: Pulse Width $\leq$ 300 μs. Duty Cycle $\leq$ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2010, MJE2011 PNP (SILICON)
MJE2020, MJE2021 NPN

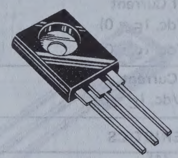
COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in general-purpose amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 3.5 Adc
- High DC Current Gain — h_{FE} = 25-125 @ I_C = 1.0 Adc

5.0 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

40–60 VOLTS
80 WATTS

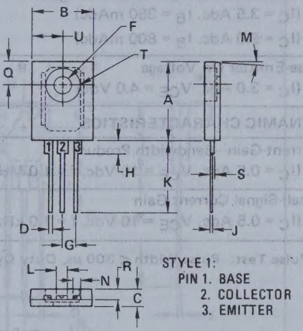


MAXIMUM RATINGS

Rating	Symbol	MJE2010 MJE2020	MJE2011 MJE2021	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →		Vdc
Collector Current — Continuous	I_C	← 5.0 →		Adc
Base Current	I_B	← 3.0 →		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 80 → 0.64		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.563	°C



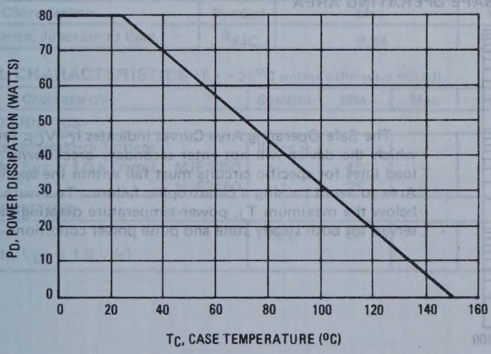
STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

FIGURE 1 — POWER TEMPERATURE DERATING CURVE

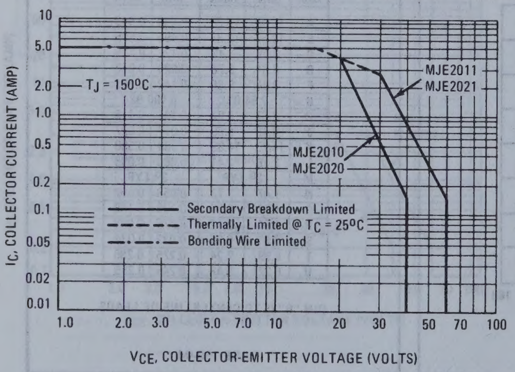


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	 MJE2010, MJE2020 MJE2011, MJE2021	$V_{CEO(sus)}$	 40 60	 – –	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)		I_{CEO}	–	0.7	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0) (V_{CE} = 60 Vdc, V_{BE} = 0)	 MJE2010, MJE2020 MJE2011, MJE2021	I_{CES}	 – –	 0.4 0.4	mAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 MJE2010, MJE2020 MJE2011, MJE2021	I_{CBO}	 – –	 0.4 0.4	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain[1] (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)		h_{FE}	 25 15	 125 –	–
Collector-Emitter Saturation Voltage[1] (I_C = 3.5 Adc, I_B = 350 mAdc) (I_C = 5.0 Adc, I_B = 800 mAdc)		$V_{CE(sat)}$	 – –	 1.0 1.5	Vdc
Base-Emitter On Voltage (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.6	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	–	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicates I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2050 NPN (SILICON)
MJE2150 PNP

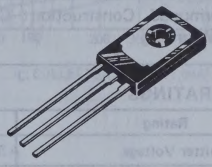
Advance Information

COMPLEMENTARY SILICON POWER TRANSISTORS

. . . designed to be used in conjunction with the MC1385P audio driver integrated circuit to produce a Class B audio amplifier suitable for auto radio applications.

5.0 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

25, 45 VOLTS
15 WATTS



MAXIMUM RATINGS

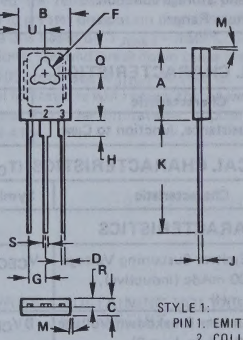
Rating	Symbol	MJE2050	MJE2150	Unit
Collector-Emitter Voltage	V_{CER}	45	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous Peak	I_C	5.0 10		Adc
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	15 0.12		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	8.34	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted).

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 0.2$ Adc, $R_{BE} = 1.0$ k Ohms) MJE2050 MJE2150	BV_{CER}	 45 25	— – –	Vdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.8$ Adc, $V_{CE} = 1.0$ Vdc)	h_{FE}	50	–	–



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

This is advance information on a new introduction and specifications are subject to change without notice.

MJE2090 thru MJE2093 (SILICON)

For Specifications, See MJE1090 Data.

MJE2100 thru MJE2103 (SILICON)

For Specifications, See MJE1090 Data.

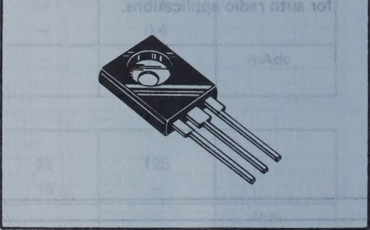
MJE2160 (SILICON)

PLASTIC MEDIUM-POWER NPN SILICON TRANSISTOR

. . . designed for line operated audio output amplifier applications in television and radio receivers; as medium power line operated series-pass and switching regulators.

- High Collector-Emitter Sustaining Voltage — $V_{CEO(sus)}$ = 300 Vdc (Min) @ I_C = 10 mAdc
- Excellent DC Current Gain — h_{FE} = 30-240 @ I_C = 500 mAdc
- Thermopad Construction: Case 199 — for Metal-to-Metal Mounting

1.5 AMPERE
POWER TRANSISTOR
NPN SILICON
300 VOLTS
50 WATTS



MAXIMUM RATINGS

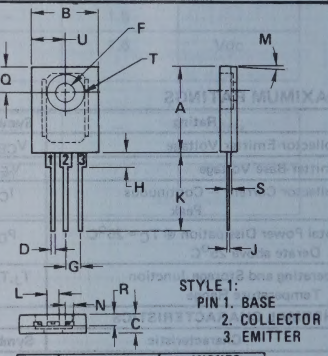
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	50 0.4	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc (inductive), L = 50 mH)	$V_{CEO(sus)}$	300	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	300	—	—	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	—	—	100	µAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	µAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 Adc, V_{CE} = 10 Vdc)	h_{FE}	 30 10	 — —	 240 —	—
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	—	—	3.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	—	1.2	Vdc
Base-Emitter Voltage Temperature Coefficient (I_C = 50 mAdc, V_{CE} = 10 Vdc) -55°C to +25°C +25°C to +150°C	θ_{VB}	 — —	 1.94 2.14	 — —	 mV/°C mV/°C



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

FIGURE 1 – DC CURRENT GAIN

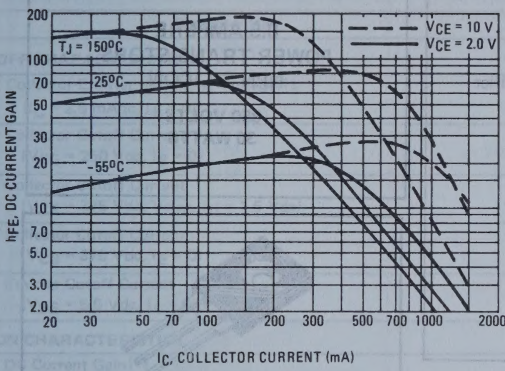


FIGURE 2 – "ON" VOLTAGES

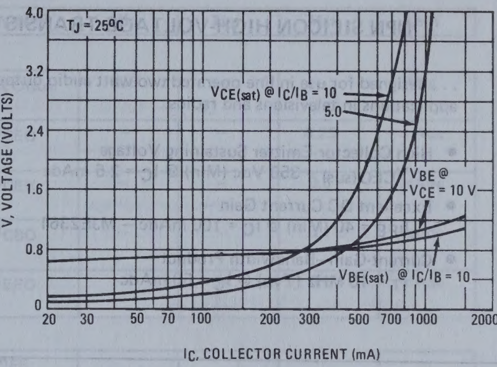
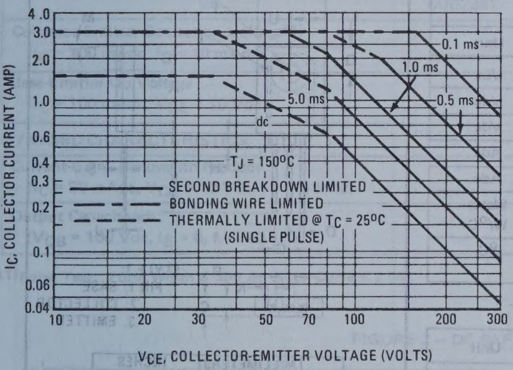


FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 4 – POWER DERATING

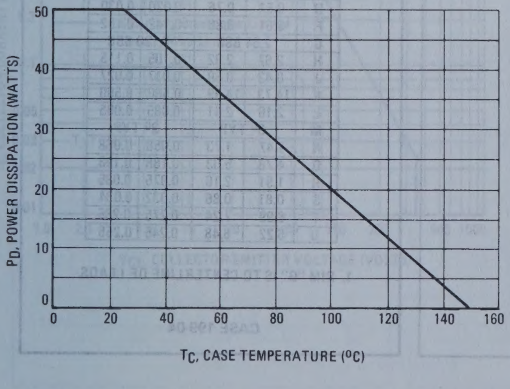
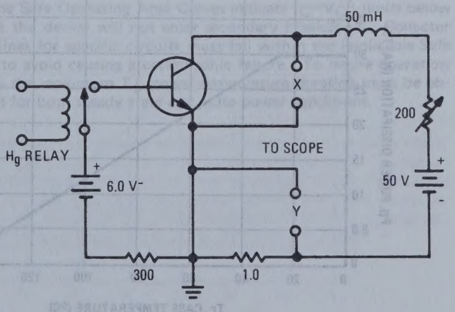


FIGURE 5 – SUSTAINING VOLTAGE TEST CIRCUIT



MJE2360 (SILICON)
MJE2361

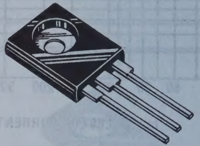
NPN SILICON HIGH-VOLTAGE TRANSISTOR

. . . designed for use in line operated two-watt audio output amplifier applications in televisions and radios.

- High Collector-Emitter Sustaining Voltage – $V_{CEO(sus)} = 350$ Vdc (Min) @ $I_C = 2.5$ mAdc
- Excellent DC Current Gain – $h_{FE} = 40$ (Min) @ $I_C = 100$ mAdc – MJE2361
- Current-Gain–Bandwidth Product – $f_T = 10$ MHz (Typ) @ $I_C = 50$ mAdc

0.5 AMPERE
POWER TRANSISTORS
NPN SILICON

350 VOLTS
30 WATTS



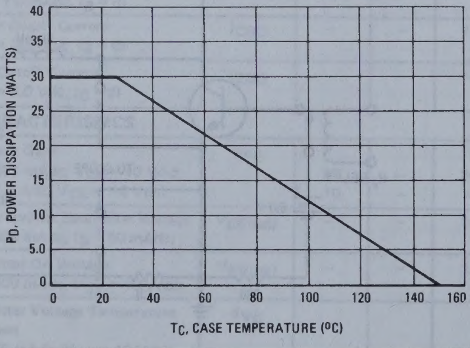
MAXIMUM RATINGS

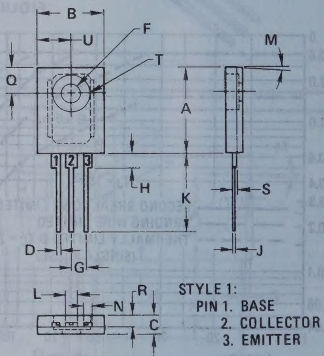
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	350	Vdc
Collector-Base Voltage	V_{CB}	375	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	0.5	Adc
Base Current	I_B	0.25	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	30 0.24	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.167	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

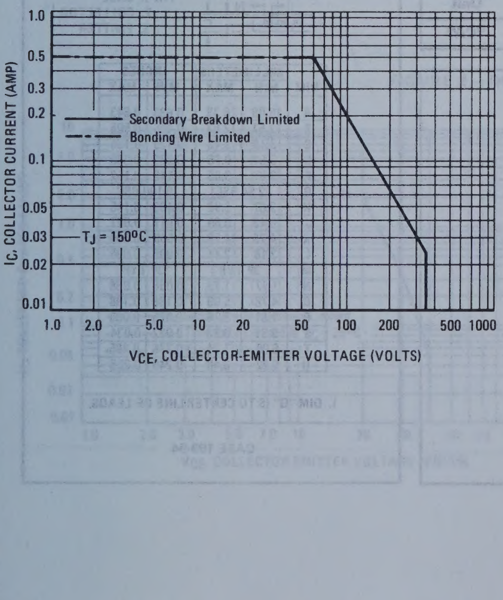
CASE 199-04

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1) (I_C = 2.5 mAdc, I_B = 0)		$V_{CEO(sus)}$	350	–	–	Vdc
Collector Cutoff Current (V_{CE} = 250 Vdc, I_B = 0)		I_{CEO}	–	–	0.25	mAdc
Collector Cutoff Current (V_{CE} = 375 Vdc, $V_{EB(off)}$ = 1.5 Vdc)		I_{CEX}	–	–	0.5	mAdc
Collector Cutoff Current (V_{CB} = 375 Vdc, I_E = 0)		I_{CBO}	–	–	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJE2360		25	–	200	
	MJE2361		50	–	250	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	MJE2360		15	–	–	
	MJE2361		40	–	–	
Collector-Emitter Saturation Voltage(1) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	–	–	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	–	10	–	MHz
Output Capacitance (V_{CB} = 100 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	–	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C–V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2370 (SILICON)

PNP SILICON MEDIUM-POWER TRANSISTOR

. . . designed for use in general-purpose amplifiers as drivers and as switches.

- Low Collector-Emitter Saturation Voltage
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- High DC Current Gain –
  h_{FE} = 40-200 @ I_C = 0.2 Adc
- Complement To NPN MJE2520

3.0 AMPERE
POWER TRANSISTOR
PNP SILICON
40 VOLTS
40 WATTS

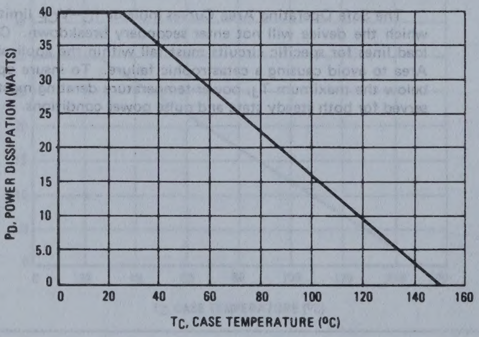
MAXIMUM RATINGS

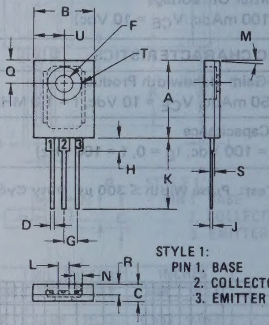
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	3.0	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.32	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.125	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

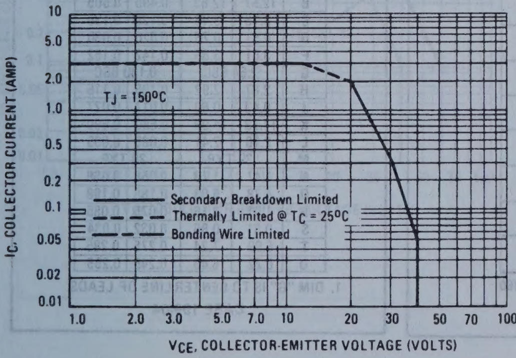
CASE 199-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 50 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	—	0.3	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}	—	0.2	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			—
(I_C = 0.2 Adc, V_{CE} = 4.0 Vdc)		40	200	
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		10	—	
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 125 mAdc)	$V_{CE(sat)}$	—	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	—	1.3	Vdc
DYNAMIC CHARACTERISTIC				
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	3.0	—	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	—	—

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 — DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2480, MJE2481 (SILICON)
MJE2482, MJE2483

NPN SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in general-purpose amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.5 Adc
- DC Current Gain — h_{FE} = 20-100 @ I_C = 2.5 Adc
- Current-Gain—Bandwidth Product — f_T = 2.0 MHz (Min) @ I_C = 1.0 Adc

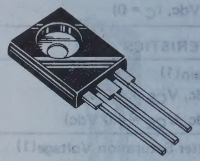
4.0 AMPERE

POWER TRANSISTORS

NPN SILICON

40-60 VOLTS

60 WATTS



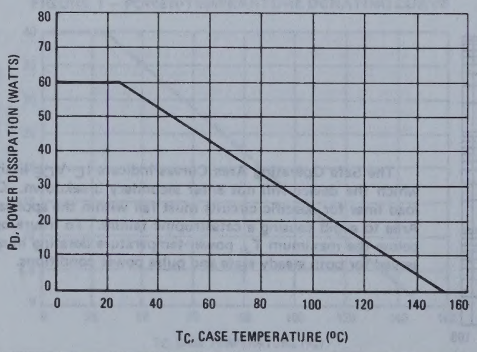
MAXIMUM RATINGS

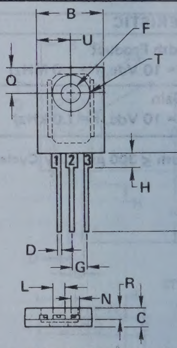
Rating	Symbol	MJE2480 MJE2482	MJE2481 MJE2483	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	4.0		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above 25°C	P_D	60 0.48		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.083	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

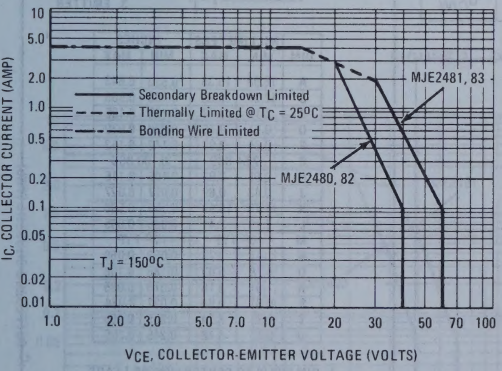
CASE 199-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	MJE2480, MJE2482		40	–	
	MJE2481, MJE2483		60	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0)	MJE2480, MJE2482		–	1.0	
(V_{CE} = 30 Vdc, I_B = 0)	MJE2481, MJE2483		–	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	MJE2480, MJE2482		–	0.1	
(V_{CB} = 60 Vdc, I_E = 0)	MJE2481, MJE2483		–	0.1	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)	All Types		40	–	
(I_C = 1.5 Adc, V_{CE} = 4.0 Vdc)	MJE2480, MJE2481		20	100	
(I_C = 2.5 Adc, V_{CE} = 4.0 Vdc)	MJE2482, MJE2483		20	100	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)			–	0.7	
(I_C = 4.0 Adc, I_B = 1.0 Adc)			–	1.4	
Base-Emitter On Voltage (I_C = 1.5 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	–	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

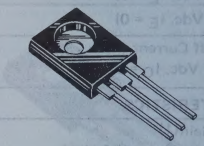
MJE2490 (SILICON)
MJE2491

PNP SILICON MEDIUM-POWER TRANSISTORS

. . . designed for use in general-purpose amplifiers as drivers and as switches.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 3.0 Adc
- High DC Current Gain — h_{FE} = 20-100 @ I_C = 1.0 Adc
- Complements to NPN MJE2522 and MJE2523

3.0 AMPERE
POWER TRANSISTORS
PNP SILICON
40-60 VOLTS
60 WATTS



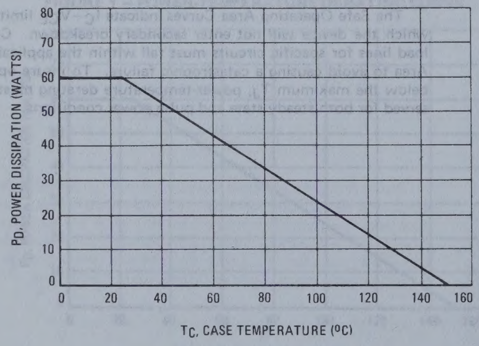
MAXIMUM RATINGS

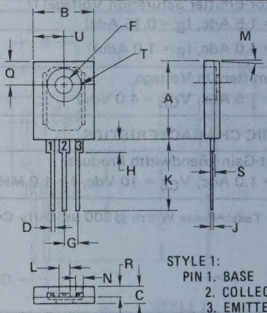
Rating	Symbol	MJE2490	MJE2491	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →		Vdc
Collector Current — Continuous	I_C	← 3.0 →		Adc
Base Current	I_B	← 1.0 →		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 ← 0.48 →		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.083	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

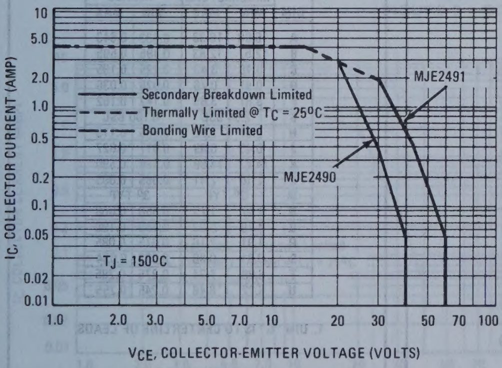
CASE 199-04

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 50 mAdc, I_B = 0)	 MJE2490 MJE2491	$V_{CEO(sus)}$	 40 60	 – –	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)		I_{CEO}	–	0.3	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0) (V_{CE} = 60 Vdc, V_{BE} = 0)	 MJE2490 MJE2491	I_{CES}	 – –	 0.2 0.2	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)		h_{FE}	 20 8.0	 100 –	–
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 100 mAdc) (I_C = 3.0 Adc, I_B = 375 mAdc)		$V_{CE(sat)}$	 – –	 0.6 1.2	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	 – –	 1.3 1.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	–	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2520 (SILICON)

NPN SILICON MEDIUM-POWER TRANSISTOR

. . . designed for use in general-purpose amplifiers as drivers and as switches.

- Low Collector-Emitter Saturation Voltage
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- High DC Current Gain –
  h_{FE} = 40-200 @ I_C = 0.2 Adc
- Complement To PNP MJE2370

3.0 AMPERE
POWER TRANSISTOR
NPN SILICON

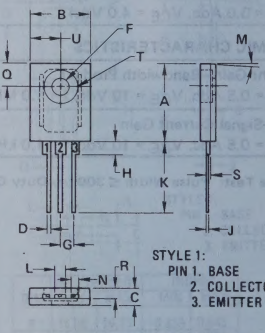
40 VOLTS
40 WATTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	3.0	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.32	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.125	°C/W



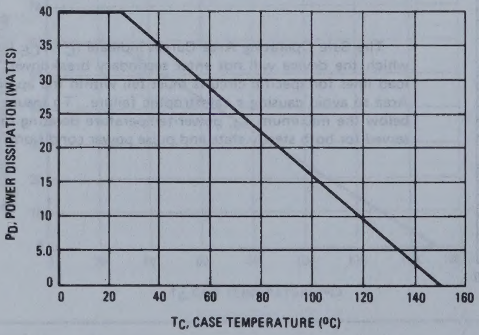
STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE

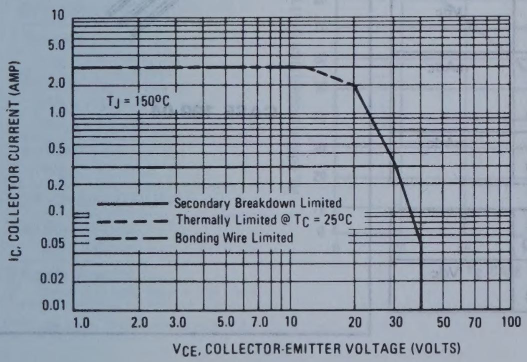


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 50 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	0.3	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}	–	0.2	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 0.2 Adc, V_{CE} = 4.0 Vdc)		40	200	
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage(1) (I_C = 1.0 Adc, I_B = 125 mAdc)	$V_{CE(sat)}$	–	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTIC				
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	3.0	–	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	–	–

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE2801 (SILICON)
MJE2801K

HIGH-POWER NPN SILICON TRANSISTOR

. . . for use as an output device in complementary audio amplifiers up to 35-Watts music power per channel.

- High DC Current Gain — h_{FE} = 25-100 @ I_C = 3.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to PNP MJE2901, MJE2901K
- Choice of Packages — MJE2801-Case 90
  MJE2801K-Case 199

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	10	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	90 0.72	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	60	—	Vdc
Collector-Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	 — —	 0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	—
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	—	1.4	Vdc

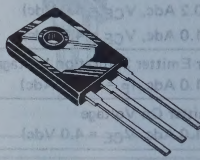
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

10 AMPERE
POWER TRANSISTORS

NPN SILICON

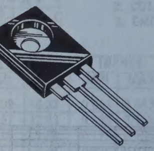
60 VOLTS
90 WATTS

MJE2801



CASE 90-05

MJE2801K



CASE 199-04

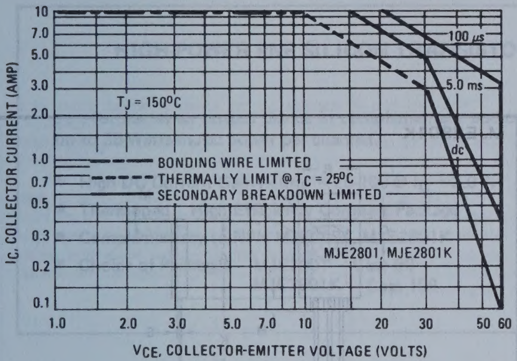


FIGURE 1 – ACTIVE REGION SAFE OPERATING AREA

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 150°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

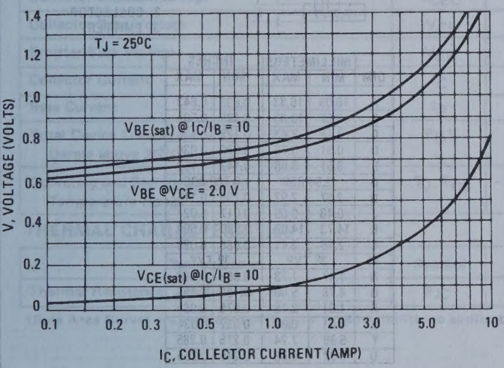


FIGURE 2 – "ON" VOLTAGES

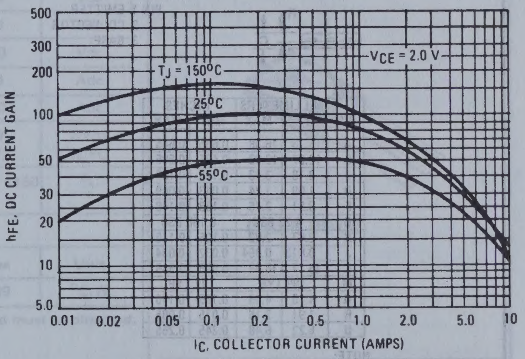


FIGURE 3 – DC CURRENT GAIN

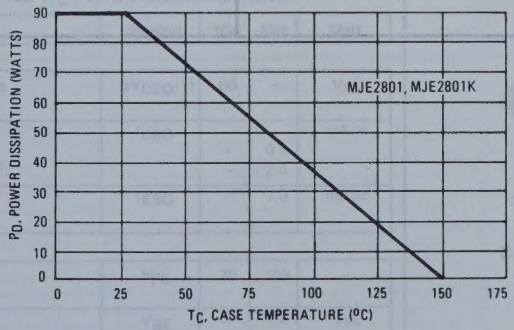
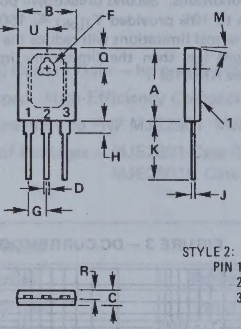


FIGURE 4 – POWER DERATING

MJE2801



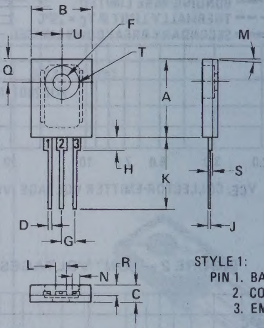
STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

CASE 90-05

MJE2801K



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE2901 (SILICON)
MJE2901K

HIGH-POWER PNP SILICON TRANSISTORS

. . . for use as an output device in complementary audio amplifiers up to 35-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 3.0 A
- Thermopad   High Efficiency Compact Package
- Complementary to NPN MJE2801, MJE2801K
- Choice of Packages – MJE2901 – Case 90
  MJE2901K – Case 199

10 AMPERE
POWER TRANSISTORS

PNP SILICON

60 VOLTS
90 WATTS

MAXIMUM RATINGS

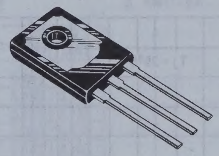
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	10	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	90 0.72	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

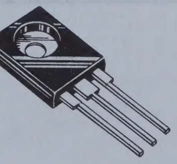
†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

MJE2901



CASE 90-05

MJE2901K



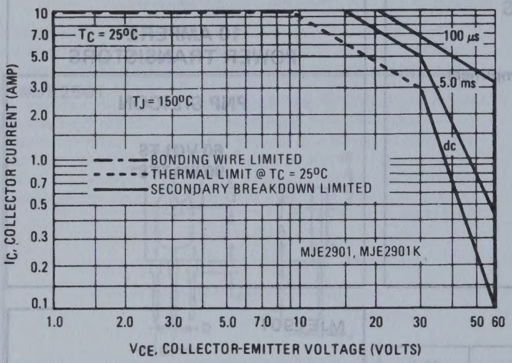
CASE 199-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	BV_{CEO}(1)	60	–	Vdc
Collector-Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	 – –	 0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	–
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	–	1.4	Vdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 2 – "ON" VOLTAGES

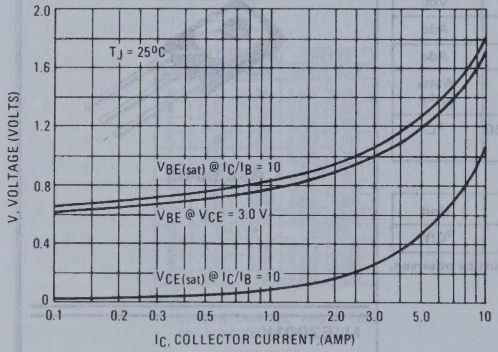


FIGURE 3 – CURRENT GAIN

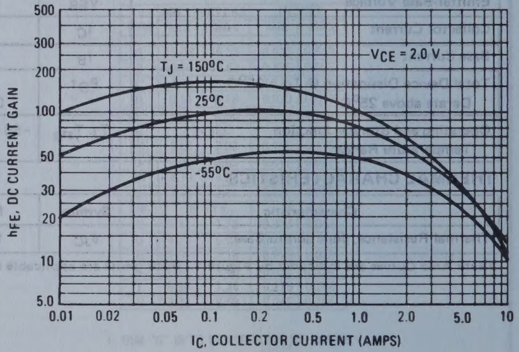
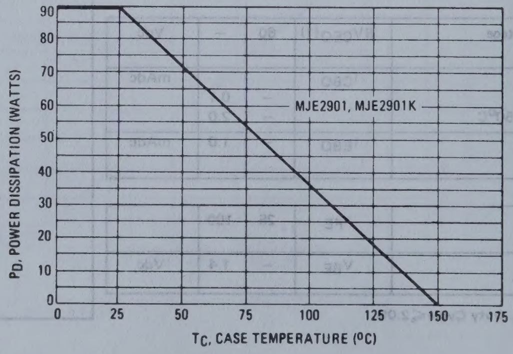
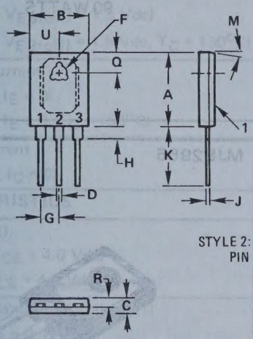


FIGURE 4 – POWER DERATING



MJE2901



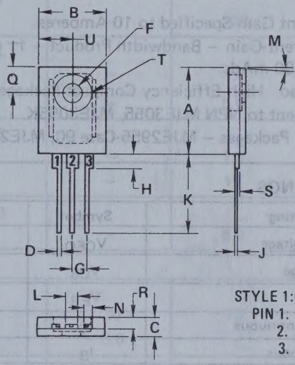
STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

CASE 90-05

MJE2901K



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE2955 (SILICON)
MJE2955K

HIGH POWER PNP SILICON TRANSISTORS

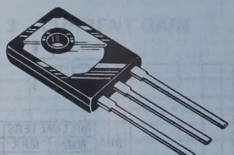
. . . designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 10 Amperes
- High Current-Gain – Bandwidth Product – f_T = 2.0 MHZ (Min) @ I_C = 500 mAdc
- Thermopad High-Efficiency Compact Package
- Complement to NPN MJE3055, MJE3055K
- Choice of Packages – MJE2955-Case 90, MJE2955K-Case 199

10 AMPERE
POWER TRANSISTORS
PNP SILICON

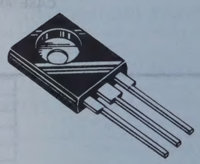
60 VOLTS
90 WATTS

MJE2955



CASE 90-05

MJE2955K



CASE 199-04

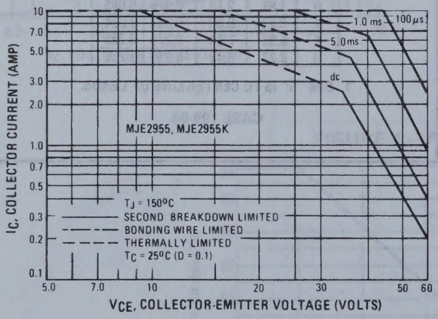
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	10	Adc
Base Current-Continuous	I_B	6.0	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	90 0.718	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

FIGURE 1 – ACTIVE REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

(1) Safe Area Curves are indicated by Figure 1 – Both thermal and safe area limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	700	μAdc
Collector Cutoff Current (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, $T_C = 150^oC$)	I_{CEX}	– –	1.0 5.0	mAdc
Collector Cutoff Current (V_{CB} = 70 Vdc, I_E = 0) (V_{CB} = 70 Vdc, I_E = 0, $T_C = 150^oC$)	I_{CBO}	– –	1.0 10	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	20 5.0	70 –	–
Collector-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	– –	1.1 8.0	Vdc
Base-Emitter On Voltage (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 500 kHz)	f_T	2.0	–	MHz

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 2 – DC CURRENT GAIN

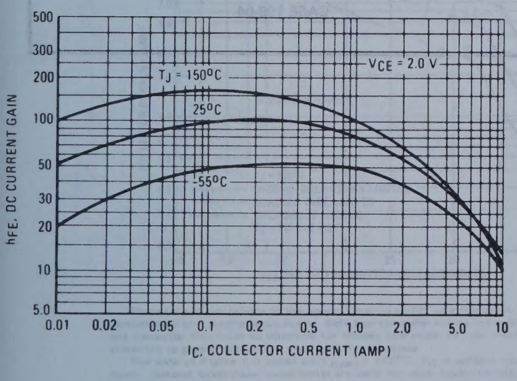
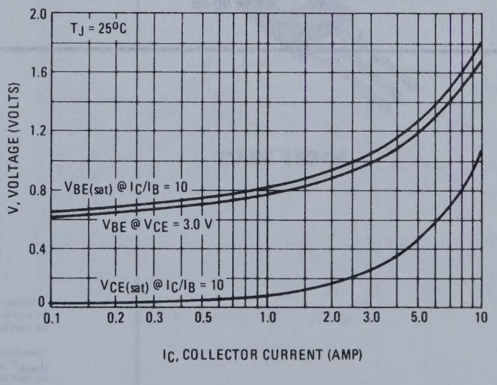
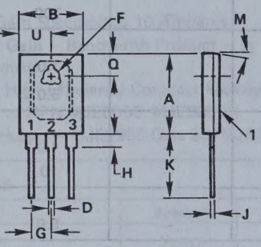
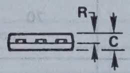


FIGURE 3 – "ON" VOLTAGES



MJE2955





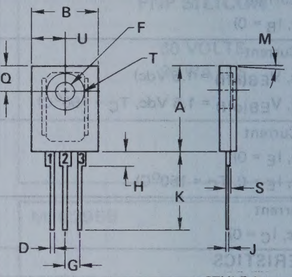
STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

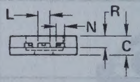
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

NOTE:
1. LEADS WITHIN .005" RAD OF TRUE POSITION (TP) AT MMC

CASE 90-05

MJE2955K





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE3055 (SILICON)
MJE3055K

HIGH POWER NPN SILICON TRANSISTORS

. . . designed for use in general-purpose amplifier and switching applications.

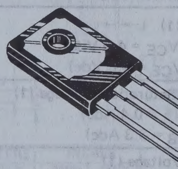
- DC Current Gain Specified to 10 Amperes
- High Current Gain — Bandwidth Product — f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Thermopad High-Efficiency Compact Package
- Complement to PNP MJE2955, MJE2955K
- Choice of Packages — MJE3055 — Case 90
  MJE3055K — Case 199

10 AMPERE
POWER TRANSISTORS

NPN SILICON

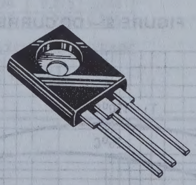
60 VOLTS
90 WATTS

MJE3055



CASE 90-05

MJE3055K



CASE 199-04

MAXIMUM RATINGS

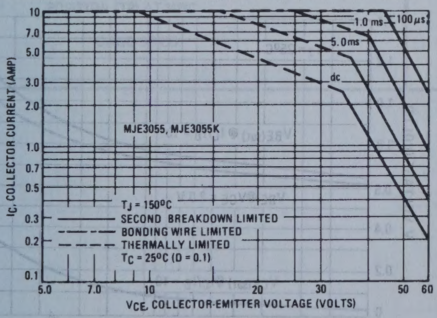
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	10	Adc
Base Current — Continuous	I_B	6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	90 0.718	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

(1) Safe Area Curves are indicated by Figure 1 — Both thermal and safe area limits are applicable and must be observed.

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	—	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	—	700	μAdc
Collector Cutoff Current (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	 —	 1.0 5.0	mAdc
Colltector Cutoff Current (V_{CB} = 70 Vdc, I_E = 0) (V_{CB} = 70 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	 — —	 1.0 10	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	—	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	 20 5.0	 70 —	—
Collector-Emitter Saturation Voltage (1) (I_C = 4.0 Adc, I_B = 0.4 Adc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	 — —	 1.1 8.0	Vdc
Base-Emitter On Voltage (1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	—	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain — Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 500 kHz)	f_T	2.0	—	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 — DC CURRENT GAIN

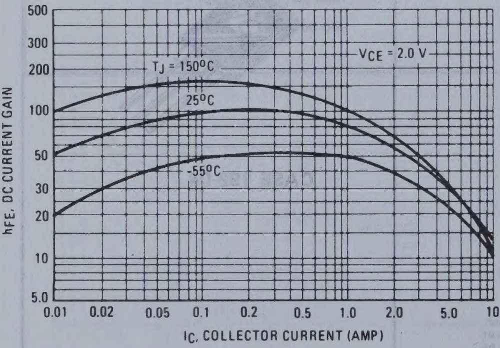
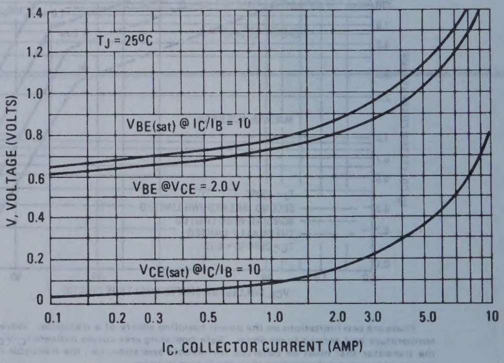
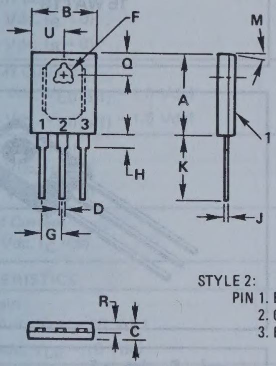


FIGURE 3 — "ON" VOLTAGES



MJE3055



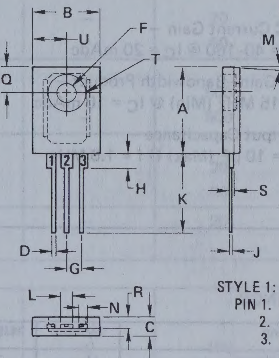
STYLE 2:
PIN 1. EMITTER
2. COLLECTOR
3. BASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.13	16.38	0.635	0.645
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	1.09	1.24	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	2.67	2.92	0.105	0.115
J	0.813	0.864	0.032	0.034
K	15.11	16.38	0.595	0.645
M	9° TYP		9° TYP	
Q	4.70	4.95	0.185	0.195
R	1.91	2.16	0.075	0.085
U	6.22	6.48	0.245	0.255

NOTE:
1. LEADS WITHIN :005" RAD OF TRUE POSITION (TP) AT MMC

CASE 90-05

MJE3055K



STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

MJE3370 (SILICON)

For Specifications, See MJE370 Data.

MJE3371 (SILICON)

For Specifications, See MJE371 Data.

MJE3439, MJE3440 (SILICON)

NPN SILICON HIGH-VOLTAGE POWER TRANSISTORS

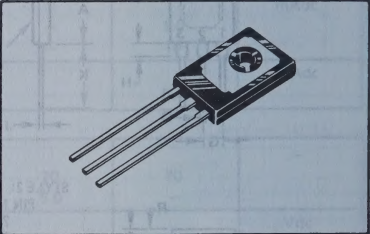
. . . designed for use as video output amplifiers in television receivers and in line operated audio output amplifiers.

- High DC Current Gain — h_{FE} = 40–160 @ I_C = 20 mAdc
- Current-Gain—Bandwidth Product — f_T = 15 MHz (Min) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 10 pF (Max) @ f = 1.0 MHz

0.3 AMPERE

NPN SILICON POWER TRANSISTORS

250–350 VOLTS
15 WATTS



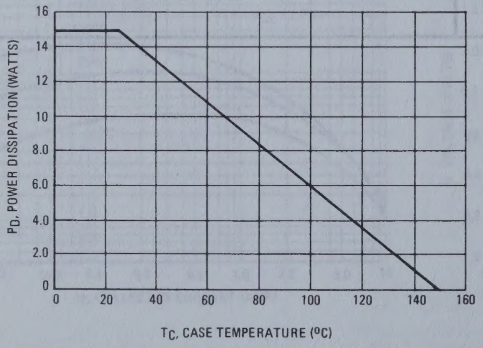
MAXIMUM RATINGS

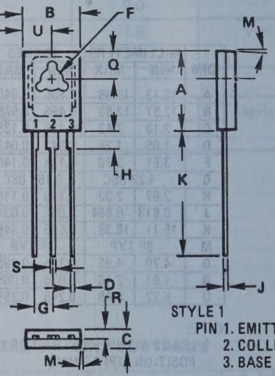
Rating	Symbol	MJE3439	MJE3440	Unit
Collector-Emitter Voltage	V_{CEO}	350	250	Vdc
Collector-Base Voltage	V_{CB}	450	350	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	0.3		Adc
Base Current	I_B	150		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.33	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





STYLE 1
PIN 1. EMITTER
2. COLLECTOR
3. BASE

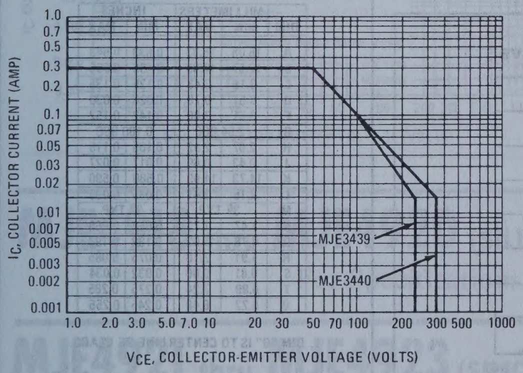
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.31	2.46	0.091	0.097
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 5.0 mAdc, I_B = 0)	MJE3439		350	–	
(I_C = 50 mAdc, I_B = 0)	MJE3440		250	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 300 Vdc, I_B = 0)	MJE3439		–	20	
(V_{CE} = 200 Vdc, I_B = 0)	MJE3440		–	50	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 450 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3439		–	500	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3440		–	500	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 360 Vdc, I_E = 0)	MJE3439		–	20	
(V_{CB} = 250 Vdc, I_E = 0)	MJE3440		–	20	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	20	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			30	–	
(I_C = 20 mAdc, V_{CE} = 10 Vdc)			40	160	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)		$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)		f_T	15	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	10	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE3520 (SILICON)

For Specifications, See MJE520 Data.

MJE3521 (SILICON)

For Specifications, See MJE521 Data.

MJE3738 (SILICON)
MJE3739

NPN SILICON HIGH-VOLTAGE TRANSISTORS

. . . designed for use in line-operated equipment such as audio output amplifiers, low-current, high-voltage converters, and AC line relay applications.

- DC Current Gain — h_{FE} = 40-200 @ I_C = 100 mAdc
- Current-Gain—Bandwidth Product — f_T = 10 MHz (Typ) @ I_C = 50 mAdc

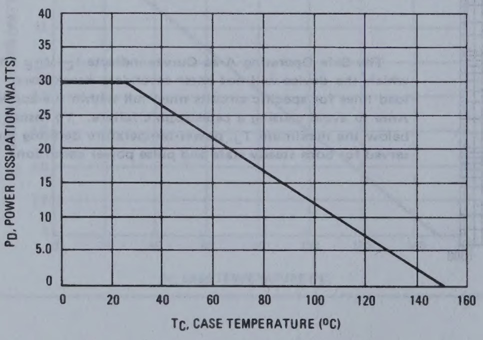
MAXIMUM RATINGS

Rating	Symbol	MJE3738	MJE3739	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	0.5		Adc
Base Current	I_B	0.5		Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above 25°C	P_D	30 0.24		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

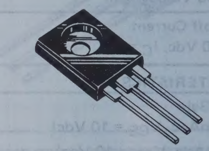
THERMAL CHARACTERISTICS

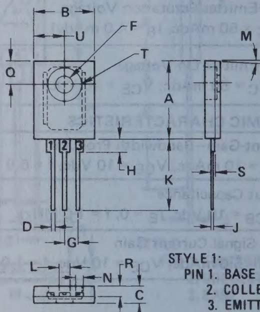
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.167	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



0.5 AMPERE
POWER TRANSISTORS
NPN SILICON
225-300 VOLTS
30 WATTS





STYLE 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTERLINE OF LEADS.

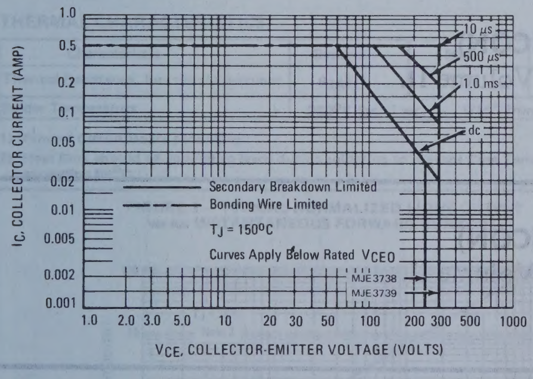
CASE 199-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1)		$V_{CEO(sus)}$				Vdc
(I_C = 30 mAdc, I_B = 0)	MJE3738		225	–	–	
(I_C = 20 mAdc, I_B = 0)	MJE3739		300	–	–	
Collector Cutoff Current		I_{CEO}				mAdc
(V_{CE} = 125 Vdc, I_B = 0)	MJE3738		–	–	0.25	
(V_{CE} = 200 Vdc, I_B = 0)	MJE3739		–	–	0.25	
Collector Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3738		–	–	0.5	
(V_{CE} = 325 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3739		–	–	0.5	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 250 Vdc, I_E = 0)	MJE3738		–	–	0.1	
(V_{CB} = 325 Vdc, I_E = 0)	MJE3739		–	–	0.1	
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			30	–	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			40	–	200	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			25	–	–	
Collector-Emitter Saturation Voltage(1) (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{CE(sat)}$	–	–	2.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	–	10	–	MHz
Output Capacitance (V_{CB} = 100 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	–	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE4918 thru MJE4920 (SILICON)

For Specifications, See 2N4918 Data, Volume I.

MJE4921 thru MJE4923 (SILICON)

For Specifications, See 2N4921 Data, Volume I.

MJE5190 thru MJE5192 (SILICON)

For Specifications, See 2N5190 Data, Volume II.

MJE5193 thru MJE5195 (SILICON)

For Specifications, See 2N5193 Data, Volume II.

MJE5655 thru MJE5657 (SILICON)

For Specifications, See 2N5655 Data, Volume II.

MJE5974 thru MJE5976 (SILICON)

For Specifications, See 2N5974 Data, Volume II.

MJE5977 thru MJE5979 (SILICON)

For Specifications, See 2N5977 Data, Volume II.

MJE5980 thru MJE5982 (SILICON)

For Specifications, See 2N5980 Data, Volume II.

MJE5983 thru MJE5985 (SILICON)

For Specifications, See 2N5983 Data, Volume II.

MJE6040 thru MJE6045 (SILICON)

For Specifications, See 2N6040 Data, Volume II.

MLED50, MLED55

VISIBLE RED LIGHT-EMITTING DIODES

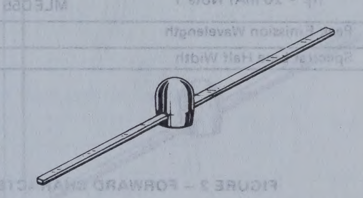
. . . designed for applications requiring high visibility, low-drive power and high reliability. These devices can be used as circuit status indicators, panel indicators in large matrix displays, and for film annotation. The MLED50 is a high intensity point source in a clear plastic package. The MLED55, because of its diffusing red plastic package appears as a large area light source with wide viewing angle.

- High Luminous Intensity – MLED50 – 1.0 mcd (Typ)
MLED55 – 0.6 mcd (Typ)
- Solid State Reliability
- Compatible with IC's – Low Drive Current
- Economical Plastic Package – Clear or Diffusing Red
- Resistant to Shock and Vibration
- Easy Cathode Indentification – Wider Lead
- Visible Red Emission – 660 nM (Typ)

LIGHT-EMITTING DIODE
VISIBLE RED

GALLIUM
ARSENIDE PHOSPHIDE

120 MILLIWATTS



MLED50 – Clear Plastic
MLED55 – Diffusing Red Plastic

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	50	mA
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D (1)	120 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (2)	-40 to +85	°C

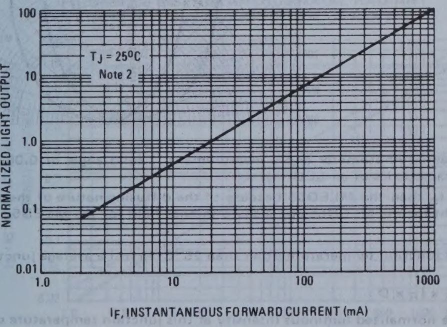
THERMAL CHARACTERISTICS

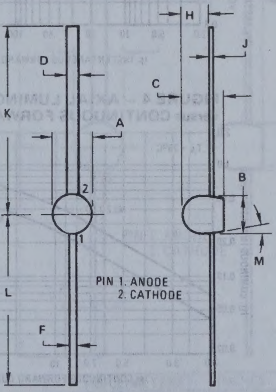
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	500	°C/W
Solder Temperature	260°C for 3 sec. – 1/16" from Case		

(1) Printed Circuit Board Mounting

(2) Heat Sink should be applied to leads during soldering to prevent Case Temperature exceeding 85°C.

FIGURE 1 – TYPICAL NORMALIZED LIGHT OUTPUT versus INSTANTANEOUS FORWARD CURRENT





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.34	2.59	0.092	0.102
B	2.11	2.36	0.083	0.093
C	2.39	2.64	0.094	0.104
D	0.66	0.71	0.026	0.028
F	0.48	0.53	0.019	0.021
H	1.57	1.83	0.062	0.072
J	0.20	0.30	0.008	0.012
K	11.30	11.43	0.445	0.450
L	10.29	10.41	0.405	0.410
M	9°	11°	9°	11°

CASE 234-02

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Instantaneous Luminous Intensity (I_F = 20 mA) Note 1			I_o				mcd
	MLED50	1		0.5	1.0	–	
	MLED55	1		0.3	0.6	–	
Peak Emission Wavelength			λp	–	660	–	nM
Spectral Line Half Width			$\Delta\lambda$	–	10	–	nM

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

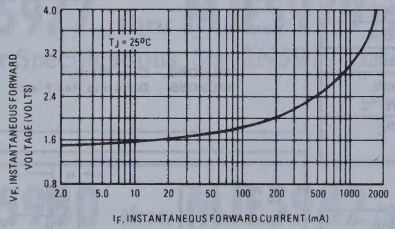


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

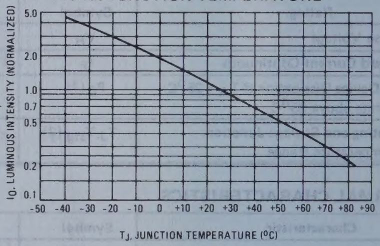


FIGURE 4 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

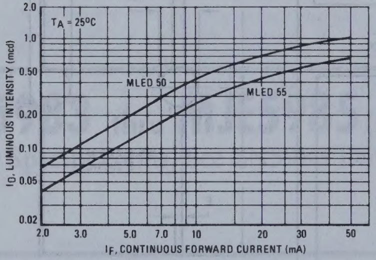
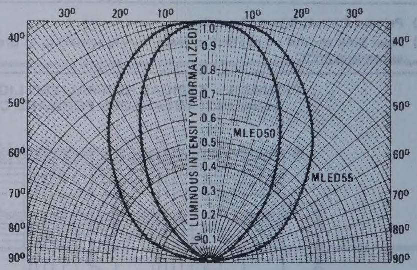


FIGURE 5 – SPATIAL RADIATION PATTERN



NOTES:

1. Axial Luminous Intensity (I_o) is measured using a CIE Corrected Photometer and a measurement solid angle of 0.003 Steradian. The spatial radiation pattern and I_o fully define the light emitting characteristics of an LED.

As seen from the specification, the MLED50 has a much higher I_o than the MLED55 because of the diffusing nature of the encapsulant used for the MLED55. The result is a large uniform field of emitted light for the MLED55 and a sharp intense field for the MLED50 as shown in Figure 5.

2. To estimate output level under non continuous current drive at junction temperature other than 25°C, first the average junction temperature can be calculated from

$$T_{J(av)} = T_A + \theta_{JA} \times V_F \times I_F \times D$$

where D is the duty cycle of the applied current (I_F). Then the normalized luminous intensity at this junction temperature can be read from Figure 3. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

*International Commission on Illumination

MLED60
MLED90

INFRARED-EMITTING DIODES

. . . designed for applications requiring high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card and tape readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High Intensity – 550 μW/str (Typ) @ I_F = 50 mA – MLED60
  350 μW/str (Typ) @ I_F = 50 mA – MLED90
- Infrared Emission – 900 nM (Typ)
- Low Drive Current – Compatible with Integrated Circuits
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package
- Small Size for High Density Mounting
- Easy Cathode Identification – Wider Lead

MAXIMUM RATINGS

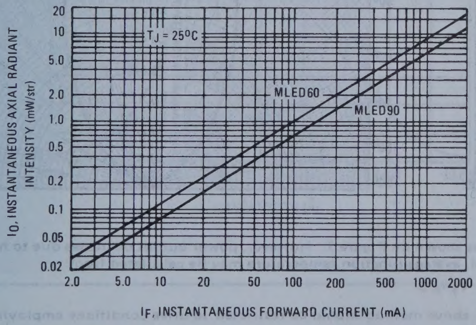
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	80	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	120 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,Tstg	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA} (1)	500	°C/W
Solder Temperature	260°C for 3 sec 1/16″ from case		

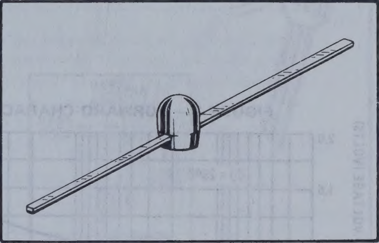
(1)Printed Circuit Board Mounting

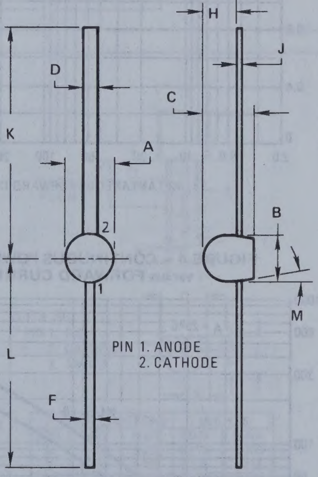
FIGURE 1 – INSTANTANEOUS AXIAL RADIANT INTENSITY versus FORWARD CURRENT



INFRARED-EMITTING DIODES
900 nM
PN GALLIUM ARSENIDE

120 MILLIWATTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.34	2.59	0.092	0.102
B	2.11	2.36	0.083	0.093
C	2.39	2.64	0.094	0.104
D	0.66	0.71	0.026	0.028
F	0.48	0.53	0.019	0.021
H	1.57	1.83	0.062	0.072
J	0.20	0.30	0.008	0.012
K	11.30	11.43	0.445	0.450
L	10.29	10.41	0.405	0.410
M	9°	11°	9°	11°

CASE 234-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 50 mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Radiant Intensity (I_F = 50 mA)	1	I_O				μW/str
MLED60			400	550	–	
MLED90			200	350	–	
Peak Emission Wavelength	–	λ_P	–	900	–	nM
Spectral Line Half Width	–	Δλ	–	40	–	nM

FIGURE 2 – FORWARD CHARACTERISTICS

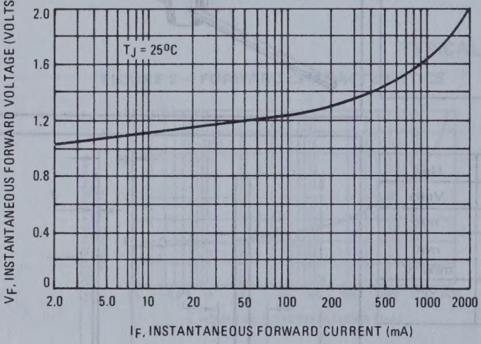


FIGURE 3 – RADIANT INTENSITY versus JUNCTION TEMPERATURE

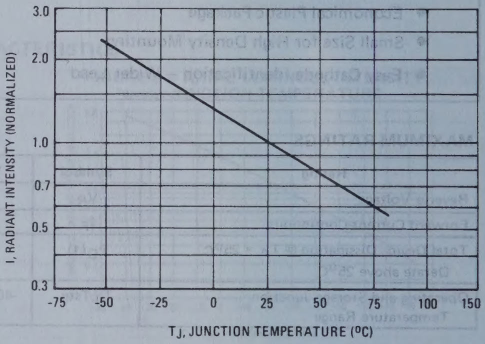


FIGURE 4 – CONTINUOUS POWER OUTPUT versus FORWARD CURRENT

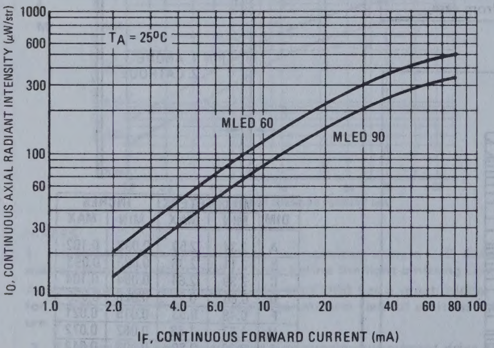
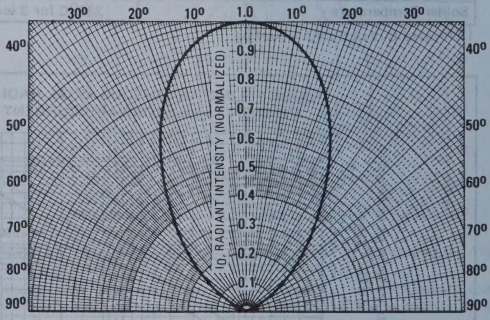


FIGURE 5 – SPATIAL RADIATION PATTERN



Output saturation effects are not evident at currents up to 2 A as shown on Figure 1. However, power output decreases due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

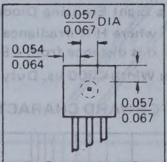
where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

INFRARED-EMITTING DIODE

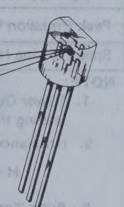
. . . designed for industrial processing and control applications such as light modulators, shaft or position encoders, end of tape detectors, and optical coupler applications. Supplied in TO-92 package for ease of mounting and compatibility with existing automatic insertion equipment.

- High Power Output— Po = 150 μW (Typ) @ I_F = 50 mA
- Infrared-Emission — 9000 Å (Typ)
- One-Piece, Unibloc Package for High Reliability

LOW COST
INFRARED-EMITTING DIODE
PN GALLIUM ARSENIDE



Die Placement Will Be Within the Boundaries of the Dotted Circle.



MAXIMUM RATINGS

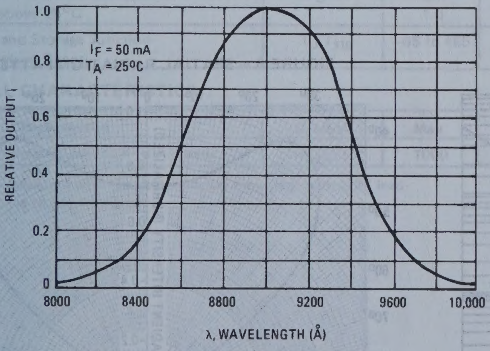
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	100	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	215 2.86	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

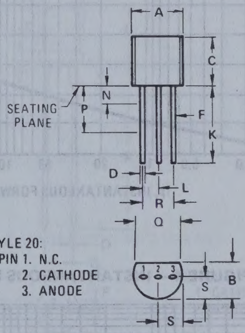
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$(1)	350	°C/W

(1) $R_{\theta JA}$(1) is measured with the device soldered into a typical printed circuit board.

FIGURE 1 — RELATIVE SPECTRAL OUTPUT





STYLE 20:
PIN 1. N.C.
2. CATHODE
3. ANODE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Instantaneous Forward Voltage (Note 3) (I_F = 50 mA)	2	v_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Notes 1 and 3) (I_F = 50 mA)	3, 4	P_o	50	150	–	μW
Radiant Intensity (Note 2) (I_F = 50 mA)		I_o	–	0.66	–	mW/steradian
Peak Emission Wavelength	1	λP	–	900	–	nM
Spectral Line Half Width	1	$\Delta\lambda$	–	40	–	nM

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

$$H = \frac{I_o}{d^2}$$

where H is irradiance in mW/cm^2, I_o is radiant intensity in mW/steradian;
d is distance from LED to the detector in cm.

3. Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

FIGURE 2 – FORWARD CHARACTERISTICS

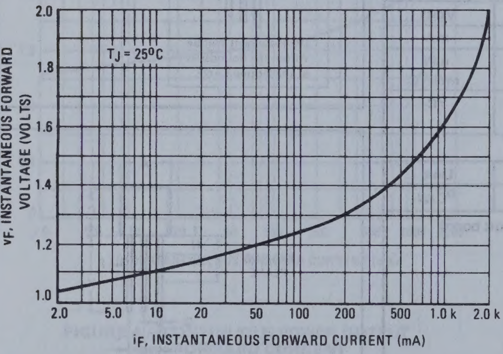


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

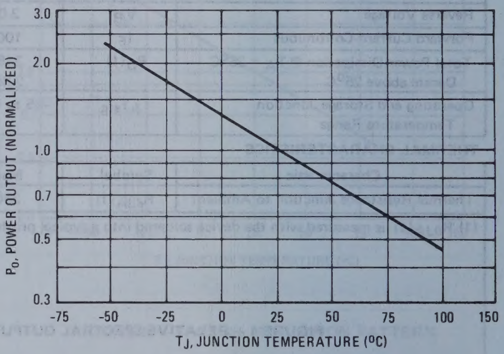


FIGURE 4 – INSTANTANEOUS POWER OUTPUT

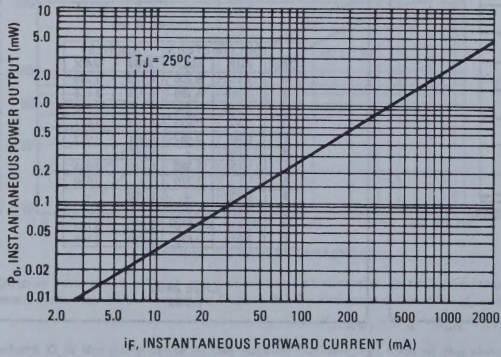
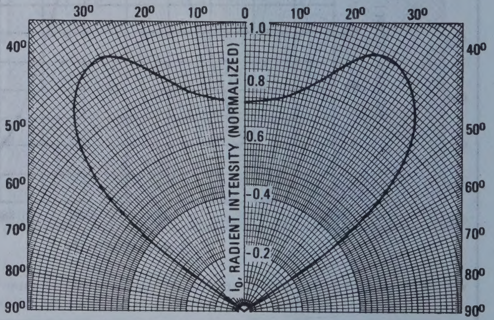


FIGURE 5 – SPATIAL RADIATION PATTERN



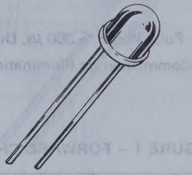
MLED440

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount applications where small size and plug-in package are desirable.

- High Luminous Intensity
- Solid State Reliability
- Diffusing White Lens
- IC Compatible – Low Power Consumption
- Wide Viewing Angle – 90°

MINIATURE
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



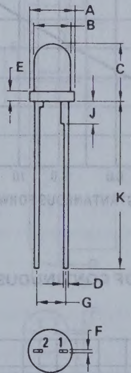
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	30	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	60 1.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$(1)	1000	°C/W

(1) $R_{\theta JA}$ is measured with the device socket mounted, with 1/8" lead from device to socket plane.



NOTE:
1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.68	3.94	0.145	0.155
B	2.92	3.18	0.115	0.125
C	4.95	5.21	0.195	0.205
D	0.38	0.48	0.015	0.019
E	0.76	1.02	0.030	0.040
F	0.20	0.30	0.008	0.012
G	2.41	2.67	0.095	0.105
J	1.78	2.03	0.070	0.080
K	12.70	–	0.500	–

CASE 292-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (2) (i_F = 20 mA)	1	v_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	3,4	I_o	0.3	1.2	–	mcd
Peak Emission Wavelength	–	λp	–	660	–	nm
Spectral Line Half Width	–	Δλ	–	10	–	nm

(1) Axial Luminous Intensity (I_o) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design.

(2) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

*International Commission on Illumination.

TYPICAL CHARACTERISTICS

FIGURE 1 – FORWARD CHARACTERISTICS

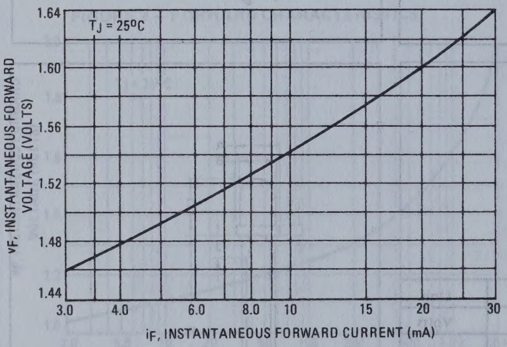
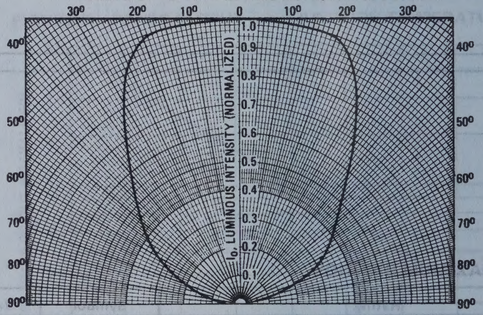


FIGURE 2 – SPATIAL RADIATION PATTERN



AXIAL LUMINOUS INTENSITY

FIGURE 3 – EFFECTS OF CONTINUOUS FORWARD CURRENT

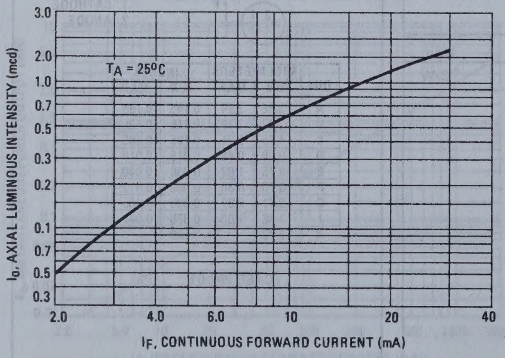
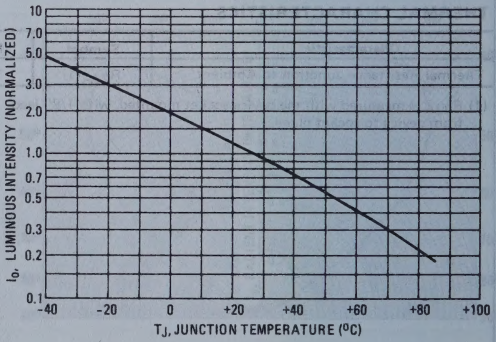


FIGURE 4 – EFFECTS OF JUNCTION TEMPERATURE



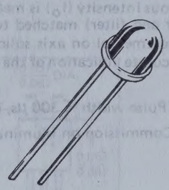
MLED445

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount applications where small size and plug-in package are desirable.

- High Luminous Intensity
- Solid State Reliability
- Water Clear Lens
- IC Compatible — Low Power Consumption
- Wide Viewing Angle — 40°

MINIATURE
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



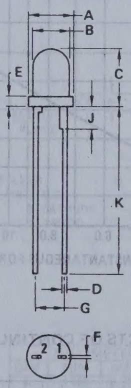
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	30	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	60 1.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$(1)	1000	°C/W

(1) $R_{\theta JA}$ is measured with the device socket mounted, with 1/8" lead from device to socket plane.



NOTE:
1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.68	3.94	0.145	0.155
B	2.92	3.18	0.115	0.125
C	4.95	5.21	0.195	0.205
D	0.38	0.48	0.015	0.019
E	0.76	1.02	0.030	0.040
F	0.20	0.30	0.008	0.012
G	2.41	2.67	0.095	0.105
J	1.78	2.03	0.070	0.080
K	12.70	–	0.500	–

CASE 292-01

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 100\ \mu A$)	–	BV_R	4.0	–	–	Volts
Forward Voltage (2) ($i_F = 20$ mA)	1	v_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	3,4	I_o	0.8	2.2	–	mcd
Peak Emission Wavelength	–	λp	–	660	–	nm
Spectral Line Half Width	–	$\Delta\lambda$	–	10	–	nm

(1) Axial Luminous Intensity (I_o) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design.

(2) Pulse Test: Pulse width ⩽ 300 μs, Duty Cycle ⩽ 2.0 %

*International Commission on Illumination.

TYPICAL CHARACTERISTICS

FIGURE 1 – FORWARD CHARACTERISTICS

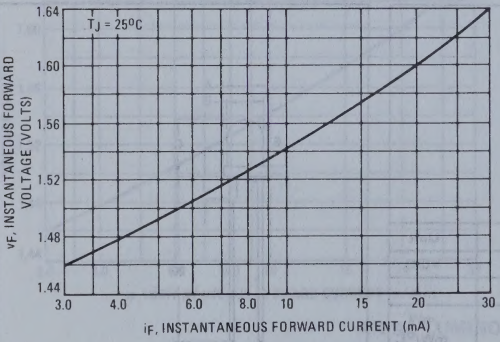
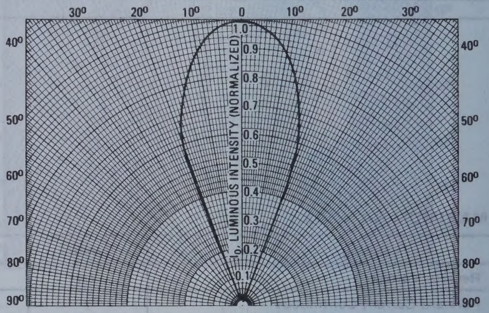


FIGURE 2 – SPATIAL RADIATION PATTERN



AXIAL LUMINOUS INTENSITY

FIGURE 3 – EFFECTS OF CONTINUOUS FORWARD CURRENT

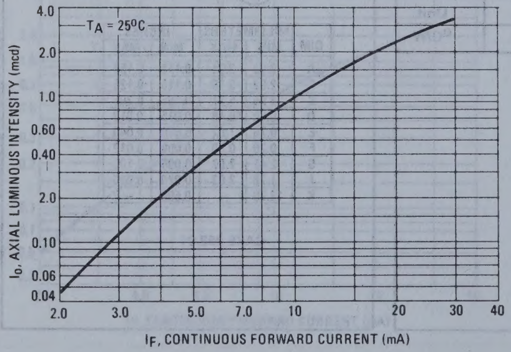
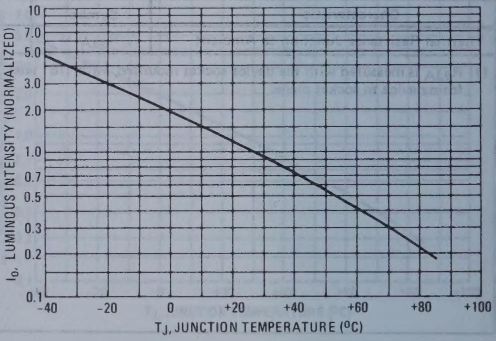


FIGURE 4 – EFFECTS OF JUNCTION TEMPERATURE



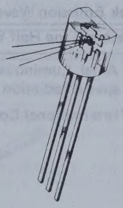
MLED500

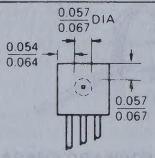
VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring visible indication of circuit status. Supplied in popular TO-92 package for ease of mounting into printed circuit board applications.

- Solid State Reliability
- Diffusing Red Lens
- IC Compatible – Low Power Consumption
- One-Piece, Injection-Molded Unibloc Package for High Reliability

LOW COST
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE





Die Placement Will Be Within the Boundaries of the Dotted Circle.

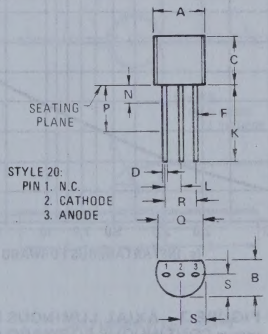
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	100	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	215 0.285	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R\theta_{JA}$(1)	350	°C/W

(1) $R\theta_{JA}$ is measured with the device soldered into a typical printed circuit board.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 100\ \mu A$)	–	BV_R	4.0	–	–	Volts
Forward Voltage ($I_F = 20$ mA)	1	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	2,3	I_o	0.1	0.3	–	mcd
Peak Emission Wavelength	–	λp	–	660	–	nM
Spectral Line Half Width	–	Δλ	–	10	–	nM

(1) Axial Luminous Intensity (I_O) is measured using a CIE* corrected Photometer and a measurement solid angle of 0.003 steradian. The spatial radiation pattern and I_O fully define the light emitting characteristics of a LED.

*International Commission on Illumination.

TYPICAL CHARACTERISTICS

FIGURE 1 – FORWARD CHARACTERISTICS

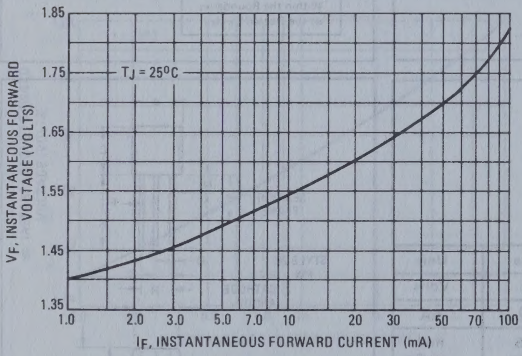


FIGURE 2 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

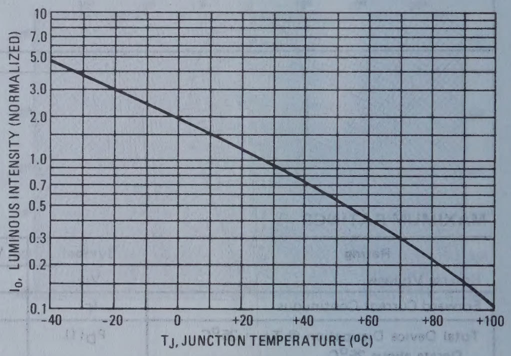


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

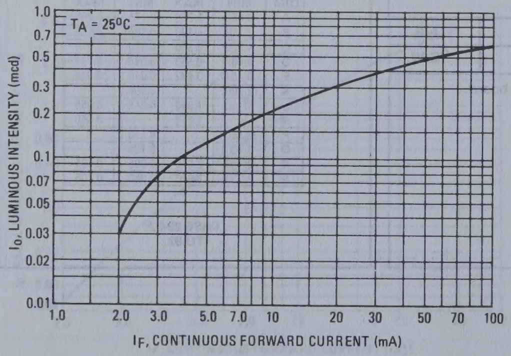
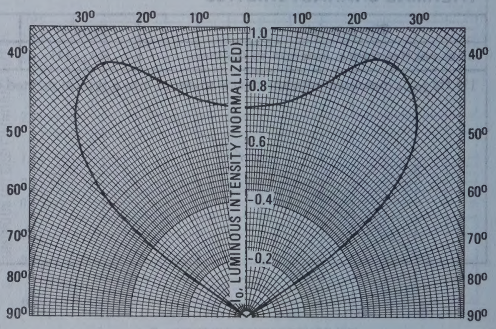


FIGURE 4 – SPATIAL RADIATION PATTERN



MLED600

VISIBLE RED LIGHT-EMITTING DIODE

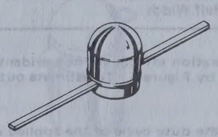
. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits.

- High Brightness — 1100 fL (Typ)
- Visible Red Emission — 6600 Å (Typ)
- Low Drive Current — 10 mA for 200 fL (Typ)
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package

LIGHT-EMITTING DIODE
VISIBLE RED

PN GALLIUM
ARSENIDE PHOSPHIDE

120 MILLIWATTS



MAXIMUM RATINGS

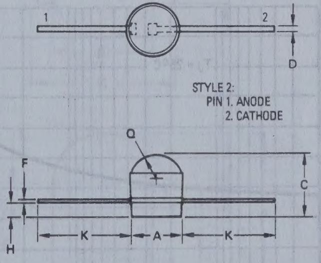
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	50	mA
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	$P_D(1)$	120 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	$T_J, T_{stg}(2)$	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	θ_{JA}	500	°C/W

(1) Printed Circuit Board Mounting

(2) Heat Sink should be applied to leads during soldering to prevent Case Temperature exceeding 85°C.



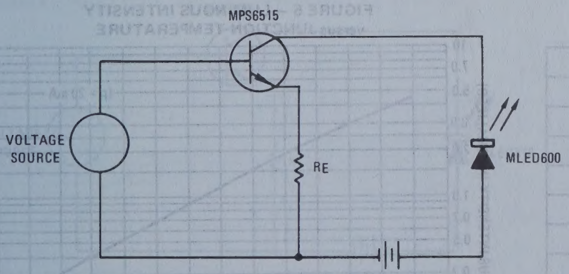
Lead 2 indicated by square bonding pad on bottom of device.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.56	4.06	0.140	0.160
C	4.57	5.33	0.180	0.210
D	0.33	0.48	0.013	0.019
F	0.23	0.28	0.009	0.011
H	1.02	1.27	0.040	0.050
K	6.35	–	0.250	–
Q	1.91 NOM		0.075 NOM	

Cathode indicated by square bonding pad on bottom of device.

CASE 171

FIGURE 1 — TYPICAL DRIVE CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 4.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Instantaneous Luminous Intensity (I_F = 20 mA)	–	I_o	1.0	3.0	–	mcd
Peak Emission Wavelength	4	λ_P	–	660	–	nM
Spectral Line Half Width	4	$\Delta\lambda$	–	10	–	nM

NOTES:

1. Output saturation effects are not evident at pulse currents up to 2 A. However, saturation does occur due to heating of the semiconductor as indicated by Figure 5. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} \cdot V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

2. Axial Luminous Intensity (I_O) is measured using a CIE* corrected Photometer and a measurement solid angle of 0.003 Steradian.

*International Commission on Illumination.

FIGURE 2 – FORWARD CHARACTERISTICS

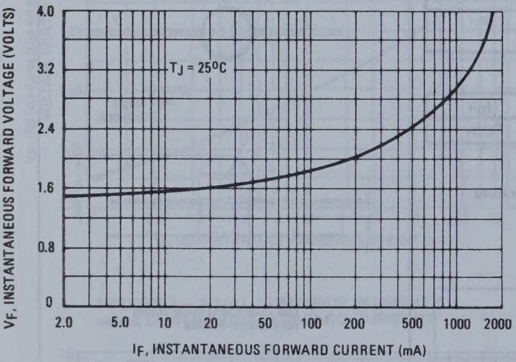


FIGURE 3 – LUMINOUS INTENSITY

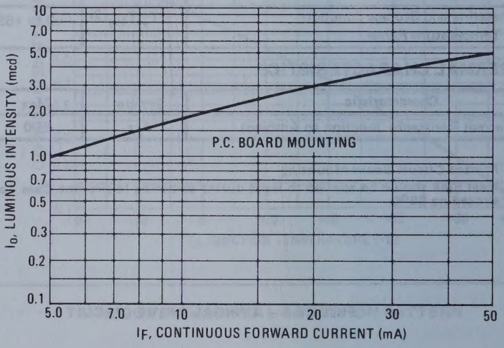


FIGURE 4 – RELATIVE INTENSITY

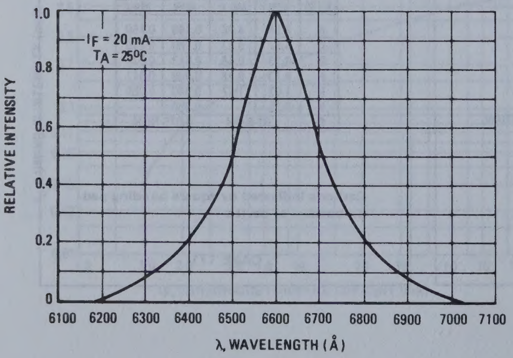
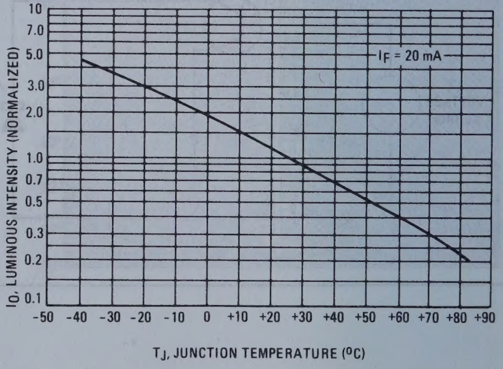


FIGURE 5 – LUMINOUS INTENSITY versus JUNCTION TEMPERATURE



MLED610

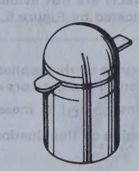
VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical data links, optical switching, and logic circuits.

- High Intensity — 3.0 mcd (Typ) — 1100 fL (Typ)
- Visible Red Emission — 6600 Å (Typ)
- Low Drive Current — 10 mA for 200 fL (Typ)
- Hermetic Pill Package for Durability, Long Life and Reliability
- Pill Package Allows Printed Circuit Board Assembly
- Small Size for High Density Mounting

LIGHT-EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE

350 MILLIWATTS



MAXIMUM RATINGS

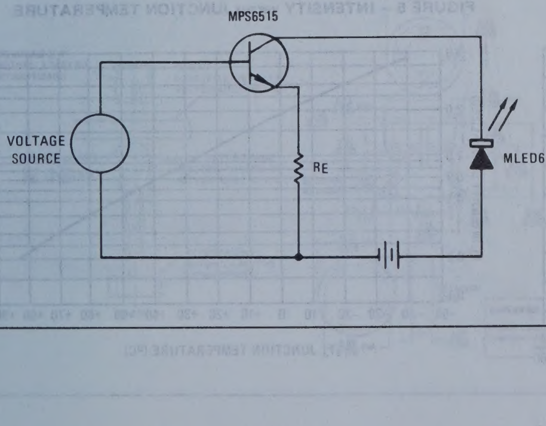
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	75	mA
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_D(1)	350 3.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +125	°C

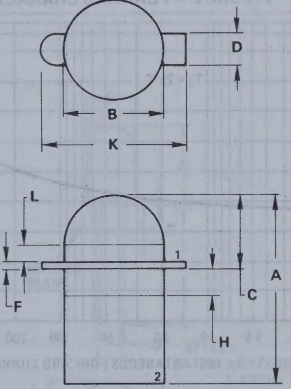
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient(1)	θ_{JA}	286	°C/W

(1) Thermal resistance, junction to case is typically 80° C/W. The mounting conditions determine the junction to ambient thermal resistance. For example, when soldered in a copper printed circuit board through a 1/8" diameter pad on the top to a 1/4" x 1/4" pad on the bottom surface, values of the 160° C/W will occur. If both pads are 1/8" in diameter, thermal resistance is typically 250° C/W; the limit of 286° C/W is specified for the latter mounting condition.

FIGURE 1 — TYPICAL DRIVE CIRCUIT





STYLE 2:
TERM 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.79	3.30	0.100	0.130
B	1.47	1.57	0.058	0.062
C	0.71	1.02	0.028	0.040
D	0.41	0.61	0.016	0.024
F	0.13	0.25	0.005	0.010
H	0.48	0.53	0.019	0.021
K	2.11	2.36	0.083	0.093
L	0.20	0.30	0.008	0.012

CASE 81A-05

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current ($V_R = 4.0$ V, $R_L = 1.0$ Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage ($I_R = 100\ \mu A$)	–	BV_R	4.0	–	–	Volts
Forward Voltage ($I_F = 20$ mA)	2	V_F	–	1.6	2.0	Volts
Total Capacitance ($V_R = 0$ V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Instantaneous Luminous Intensity		I_o	0.8	3.0	–	mcd
Peak Emission Wavelength	4	λ_P	–	660	–	nM
Spectral Line Half Width	4	$\Delta\lambda$	–	10	–	nM

NOTE:

1. Output saturation effects are not evident at currents up to 2 A as shown on Figure 3. However, saturation does occur due to heating of the semiconductor as indicated by Figure 5. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

2. Axial Luminous Intensity (I_O) is measured using a CIE* corrected Photometer and a measurement solid angle of 0.003 Steradian.

*International Commission on Illumination.

FIGURE 2 – FORWARD CHARACTERISTICS

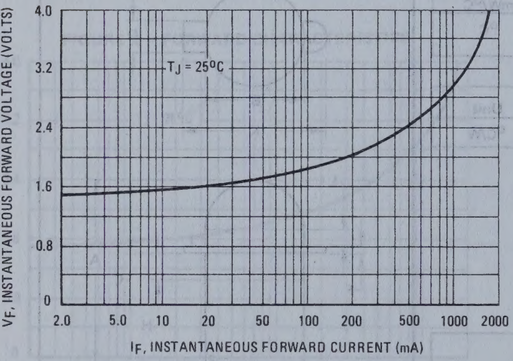


FIGURE 3 – INSTANTANEOUS INTENSITY

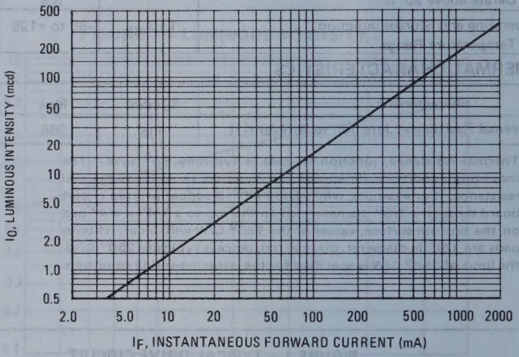


FIGURE 4 – RELATIVE INTENSITY

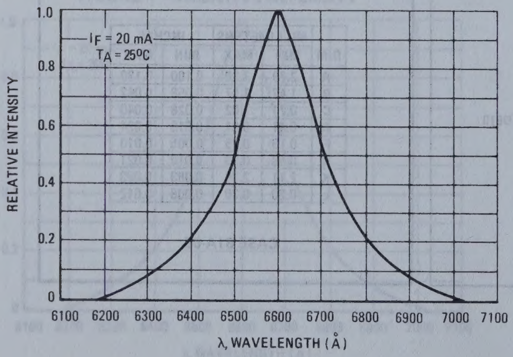
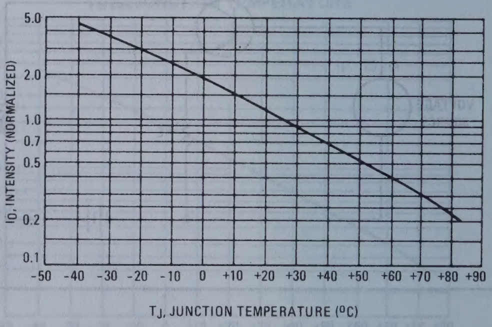


FIGURE 5 – INTENSITY versus JUNCTION TEMPERATURE



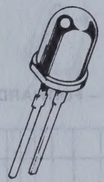
MLED640

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount indicator applications. Ideally suited for mounting in panels to 0.125" thick using plastic snap-in retainer.

- High Luminous Intensity
- Economical Plastic Package
- Solid State Reliability
- White Diffusing Lens

PANEL MOUNT
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



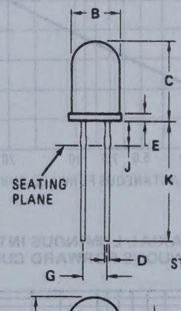
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	60	mA
Total Device Dissipation @ $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D(1)	100 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}$(1)	600	°C/W

(1) Mounted in metal panel (see Figure 1)


B
C
E
J
K
SEATING PLANE
D
G
A
F
R
2
1

STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.72	5.97	0.225	0.235
B	4.95	5.21	0.195	0.205
C	8.38	8.89	0.330	0.350
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	0.30	0.46	0.012	0.018
G	2.44	2.64	0.096	0.104
J	2.44	2.54	0.096	0.100
K	12.57	13.21	0.495	0.520
R	2.54	2.79	0.100	0.110

CASE 279-01

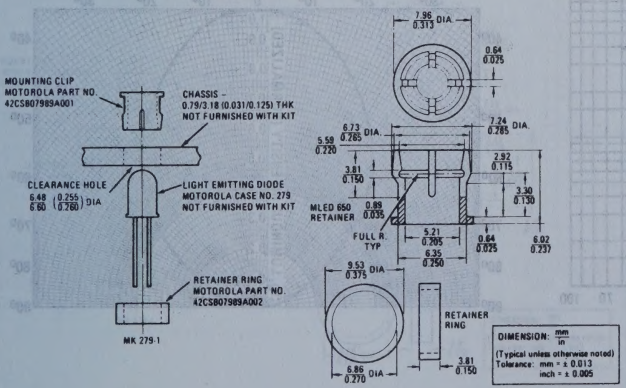


FIGURE 1 – HARDWARE DIMENSIONS

MOUNTING CLIP
MOTOROLA PART NO.
42CSB07989A001
CHASSIS –
0.79/3.18 (0.031/0.125) THK
NOT FURNISHED WITH KIT
CLEARANCE HOLE
6.48/6.60 (0.255/0.260) DIA
LIGHT EMITTING DIODE
MOTOROLA CASE NO. 279
NOT FURNISHED WITH KIT
RETAINER RING
MOTOROLA PART NO.
42CSB07989A002
MK 279-1
7.96/0.313 DIA.
0.64/0.025
6.73/0.265 DIA.
7.24/0.285 DIA.
5.59/0.220
3.81/0.150
2.92/0.115
3.30/0.130
MLED 650
RETAINER
0.89/0.035
FULL R.
TYP
5.21/0.205
6.35/0.250
0.64/0.025
6.02/0.237
9.53/0.375 DIA
RETAINER
RING
6.86/0.270 DIA
3.81/0.150

DIMENSION: mm/in
(Typical unless otherwise noted)
Tolerance: mm = ± 0.013
inch = ± 0.005

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	3,4	I_o	0.8	2.0	–	mcd
Peak Emission Wavelength	–	λp	–	660	–	nM
Spectral Line Half Width	–	$\Delta\lambda$	–	10	–	nM

(1) Axial Luminous Intensity (I_O) is measured using a CIE* corrected Photometer and a measurement solid angle of 0.003 Steradium.

*International Commission on Illumination.

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

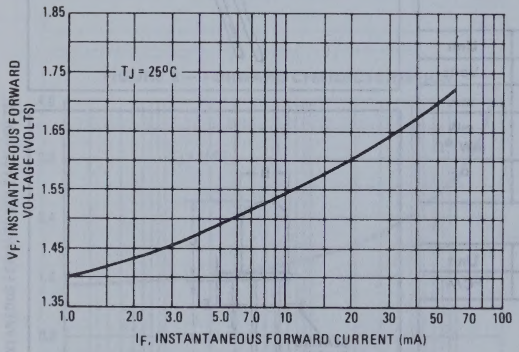


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

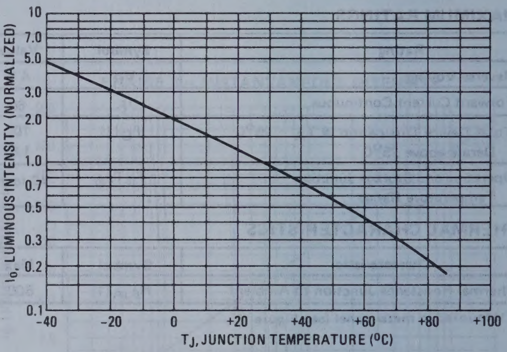


FIGURE 4 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

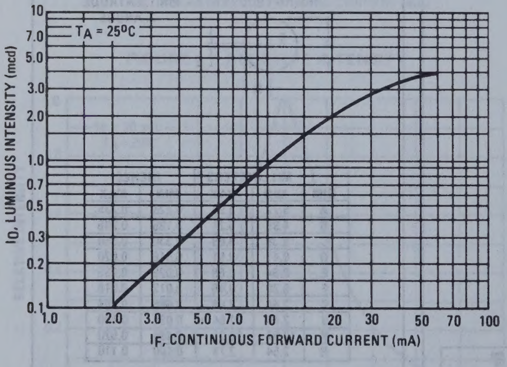
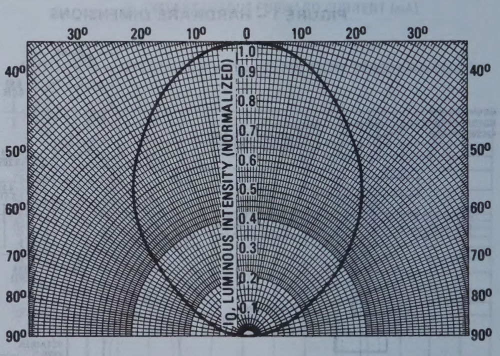


FIGURE 5 – SPATIAL RADIATION PATTERN



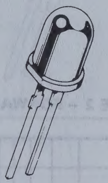
MLED655

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount indicator applications. Ideally suited for mounting in panels to 0.125″ thick using plastic snap-in retainer.

- High Luminous Intensity
- Economical Plastic Package
- Solid State Reliability
- Red Diffusing Lens

PANEL MOUNT
LIGHT EMITTING DIODE
VISIBLE RED
PN GALLIUM
ARSENIDE PHOSPHIDE



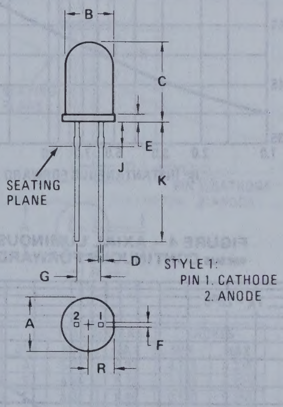
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	60	mA
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	$P_D(1)$	100 1.67	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-40 to +85	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$\theta_{JA}(1)$	600	$^oC/W$

(1) Mounted in metal panel (see Figure 1)

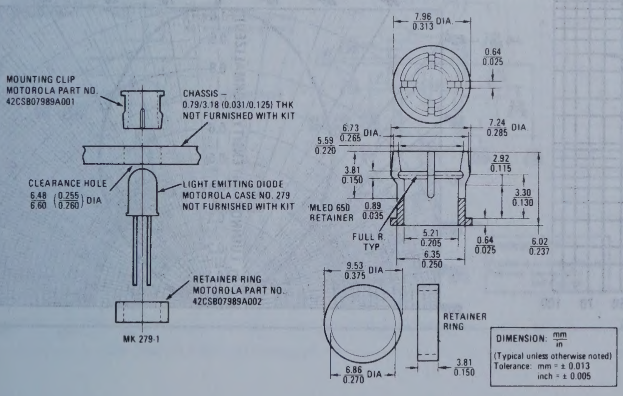


B
C
E
J
K
SEATING PLANE
D
G
STYLE 1:
PIN 1. CATHODE
2. ANODE
A
2
1
F
R

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.72	5.97	0.225	0.235
B	4.95	5.21	0.195	0.205
C	8.38	8.89	0.330	0.350
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	0.30	0.46	0.012	0.018
G	2.44	2.64	0.096	0.104
J	2.44	2.54	0.096	0.100
K	12.57	13.21	0.495	0.520
R	2.54	2.79	0.100	0.110

CASE 279-01

FIGURE 1 — HARDWARE DIMENSIONS



MOUNTING CLIP MOTOROLA PART NO. 42CSB07989A001
CHASSIS – 0.79/3.18 (0.031/0.125) THK NOT FURNISHED WITH KIT
CLEARANCE HOLE 6.48/6.60 (0.255/0.260) DIA
LIGHT EMITTING DIODE MOTOROLA CASE NO. 279 NOT FURNISHED WITH KIT
RETAINER RING MOTOROLA PART NO. 42CSB07989A002
MK 279-1
7.96/0.313 DIA.
0.64/0.025
6.73/0.265 DIA.
7.24/0.285 DIA.
5.59/0.220
2.92/0.115
3.81/0.150
3.30/0.130
MLED 650 RETAINER
0.89/0.035
FULL R. TYP
5.21/0.205
6.35/0.250
0.64/0.025
6.02/0.237
9.53/0.375 DIA
RETAINER RING
6.86/0.270 DIA
3.81/0.150
DIMENSION: mm/in
(Typical unless otherwise noted)
Tolerance: mm = ± 0.013
inch = ± 0.005

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA)	3,4	I_O	0.8	2.0	–	mcd
Peak Emission Wavelength	–	λp	–	660	–	nM
Spectral Line Half Width	–	Δλ	–	10	–	nM

(1) Axial Luminous Intensity (I_O) is measured using a CIE* corrected Photometer and a measurement solid angle of 0.003 steradian. The spatial radiation pattern and I_O fully define the light emitting characteristics of a LED.

*International Commission on Illumination.

TYPICAL CHARACTERISTICS

FIGURE 2 – FORWARD CHARACTERISTICS

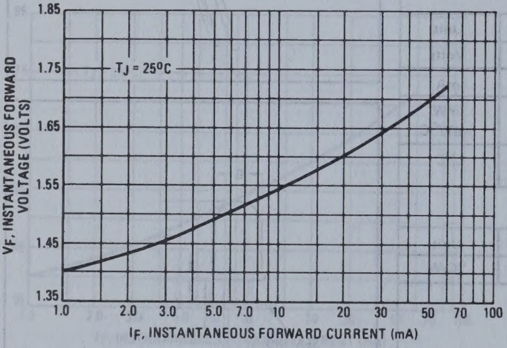


FIGURE 3 – AXIAL LUMINOUS INTENSITY versus JUNCTION TEMPERATURE

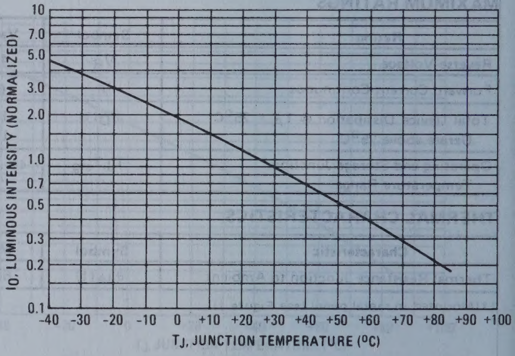


FIGURE 4 – AXIAL LUMINOUS INTENSITY versus CONTINUOUS FORWARD CURRENT

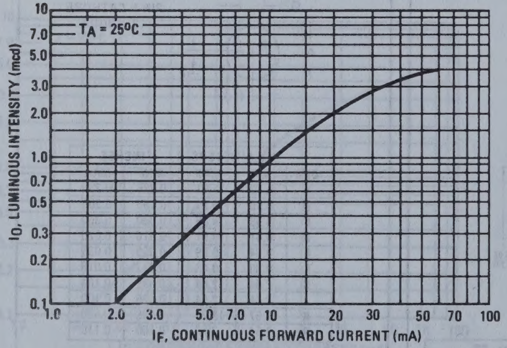
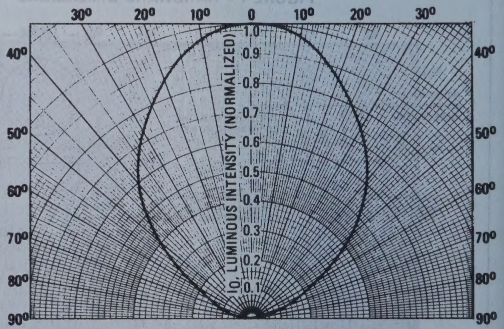


FIGURE 5 – SPATIAL RADIATION PATTERN



MLED660

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for panel mount indicator applications. Intended for mounting in standard 0.125″ panels using plastic snap-in retainer.

- High Luminous Intensity
- Economical Plastic Package
- Solid State Reliability
- Wide Viewing Angle – 90°
- High On/Off Contrasting Red Diffused Lens

PANEL MOUNT
LIGHT EMITTING DIODE
VISIBLE RED

PN GALLIUM
ARSENIDE PHOSPHIDE

DEEP RED
CONTRASTING LENS

MAXIMUM RATINGS

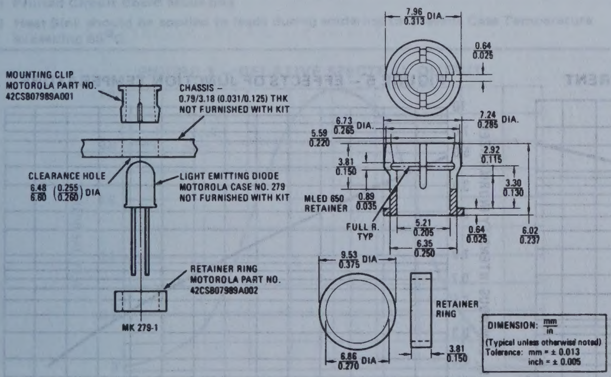
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	60	mA
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25°C	$P_D(1)$	100 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-40 to +85	°C

THERMAL CHARACTERISTICS

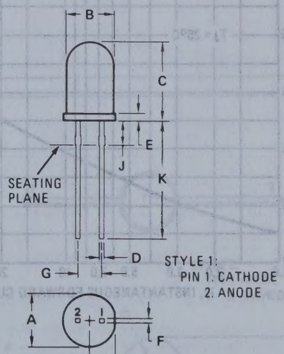
Characteristic	Symbol	Max	Unit
Thermal Resistance Junction to Ambient	$R_{\theta JA}(1)$	600	°C/W

(1) Mounted in metal panel (see Figure 1)

FIGURE 1 – HARDWARE DIMENSIONS



MOUNTING CLIP
MOTOROLA PART NO.
42CS807989A001
CHASSIS –
0.79/3.18 (0.031/0.125) THK
NOT FURNISHED WITH KIT
CLEARANCE HOLE
6.48/6.60 (0.255/0.260) DIA
LIGHT EMITTING DIODE
MOTOROLA CASE NO. 279
NOT FURNISHED WITH KIT
RETAINER RING
MOTOROLA PART NO.
42CS807989A002
MK 279-1
7.96/0.313 DIA.
0.64/0.025
6.73/0.265 DIA.
7.24/0.285 DIA.
5.59/0.220
3.81/0.150
2.92/0.115
3.30/0.130
MLED 650
RETAINER
0.89/0.035
FULL R.
TYP
5.21/0.205
6.35/0.250
0.64/0.025
6.02/0.237
9.53/0.375 DIA
RETAINER
RING
6.86/0.270 DIA
3.81/0.150
DIMENSION: mm/in
(Typical unless otherwise noted)
Tolerance: mm = ± 0.013
inch = ± 0.005



B
C
E
J
K
SEATING
PLANE
D
G
STYLE 1:
PIN 1. CATHODE
2. ANODE
A
2
1
F
R

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.72	5.97	0.225	0.235
B	4.95	5.21	0.195	0.205
C	8.38	8.89	0.330	0.350
D	0.41	0.51	0.016	0.020
E	0.64	0.89	0.025	0.035
F	0.30	0.46	0.012	0.018
G	2.44	2.64	0.096	0.104
J	2.44	2.54	0.096	0.100
K	12.57	13.21	0.495	0.520
R	2.54	2.79	0.100	0.110

CASE 279-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	4.0	–	–	Volts
Instantaneous Forward Voltage (2) (i_F = 20 mA)	2	v_F	–	1.6	2.0	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Axial Luminous Intensity (1) (IF = 20 mA) (IF = 50 mA)	4,5	I_o	 0.4 –	 0.8 1.4	 – –	mcd
Peak Emission Wavelength	–	λp	–	6600	–	Å
Spectral Line Half Width	–	Δλ	–	100	–	Å

(1) Axial Luminous Intensity (I_o) is measured using a Spectra Microcandela Light-Emitting Diode (LED) Photometer incorporating a photometric sensor (detector and filter) matched to the CIE* standard observers eye response. I_o is defined as the ratio of the luminous flux emitted by a source to an incremental on axis solid angle subtended by a sensor; i.e., candela = lumens/steradian. Since I_o is a photometric measurement, it provides an accurate indication of the visibility of an LED that includes the physical characteristics of the package such as encapsulant and lens design.

(2) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 2 – FORWARD CHARACTERISTICS

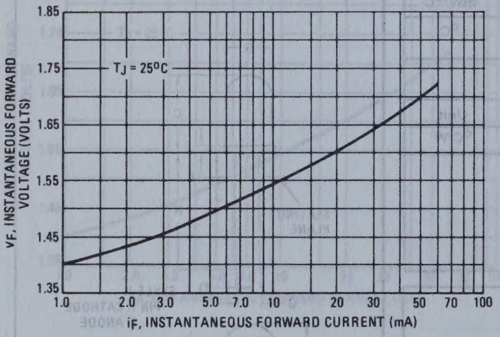


FIGURE 3 – SPATIAL RADIATION PATTERN

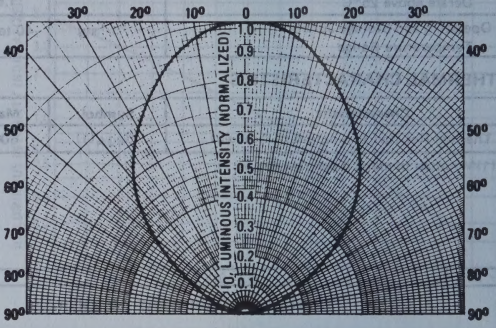


FIGURE 4 – EFFECTS OF FORWARD CURRENT

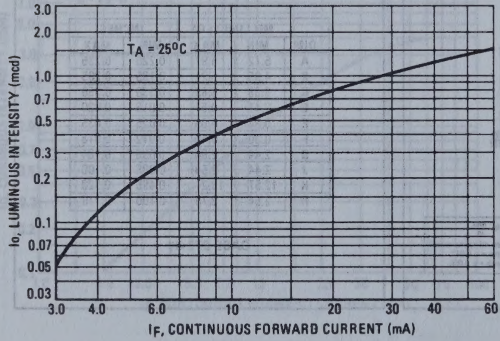
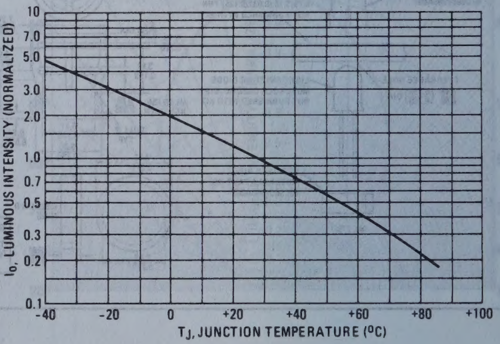


FIGURE 5 – EFFECTS OF JUNCTION TEMPERATURE



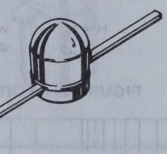
MLED900

INFRARED-EMITTING DIODE
900 nM
PN GALLIUM ARSENIDE
120 MILLIWATTS

INFRARED-EMITTING DIODE

. . . designed for applications requiring high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High Power Output — 550 µW (Typ) @ I_F = 50 mA
- Infrared Emission — 9000 Å (Typ)
- Low Drive Current — 10 mA for 120 µW (Typ)
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package



MAXIMUM RATINGS

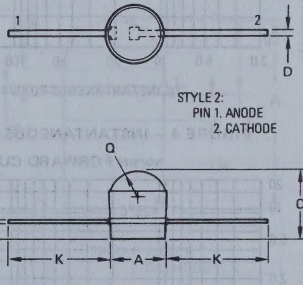
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	80	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	120 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (2)	-40 to +85	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	500	°C/W

(1) Printed Circuit Board Mounting

(2) Heat Sink should be applied to leads during soldering to prevent Case Temperature exceeding 85°C.

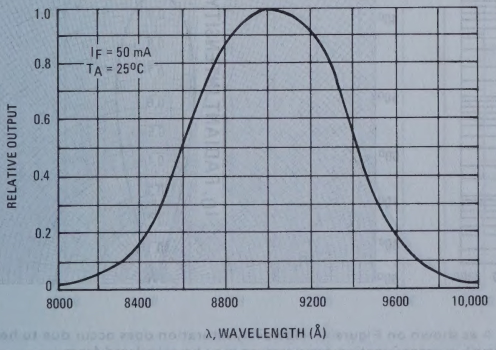


STYLE 2:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.56	4.06	0.140	0.160
C	4.57	5.33	0.180	0.210
D	0.33	0.48	0.013	0.019
F	0.23	0.28	0.009	0.011
H	1.02	1.27	0.040	0.050
K	6.35	–	0.250	–
Q	1.91 NOM		0.075 NOM	

CASE 171

FIGURE 1 — RELATIVE SPECTRAL OUTPUT



ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current ($V_R = 3.0$ V, $R_L = 1.0$ Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage ($I_R = 100\ \mu A$)	–	BV_R	3.0	–	–	Volts
Forward Voltage ($I_F = 50$ mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance ($V_R = 0$ V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Note 1) ($I_F = 50$ mA)	3, 4	P_o	200	550	–	μW
Radiant Intensity (Note 2) ($I_o = 50$ mA)		I_o	–	2.4	–	mW/steradian
Peak Emission Wavelength	1	λ_P	–	900	–	nM
Spectral Line Half Width	1	$\Delta\lambda$	–	40	–	nM

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

$$H = \frac{I_o}{d^2}$$

where H is irradiance in mW/cm², I_o is radiant intensity in mW/steradian; d is distance from LED to the detector in cm.

FIGURE 2 — FORWARD CHARACTERISTICS

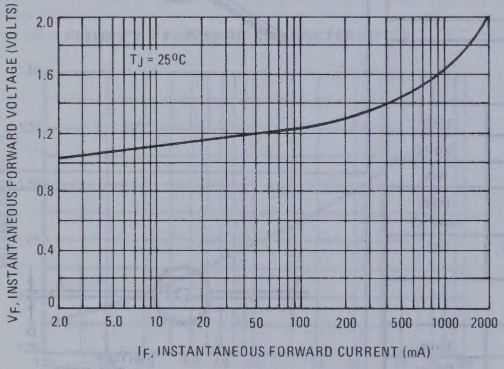


FIGURE 3 — POWER OUTPUT versus JUNCTION TEMPERATURE

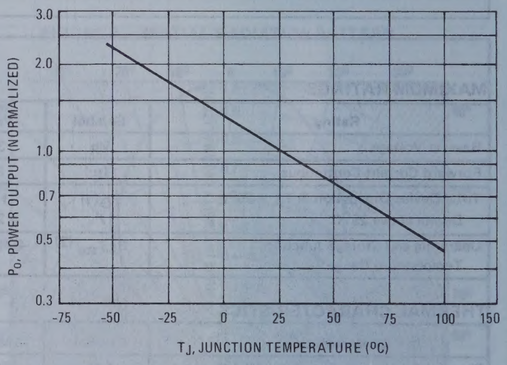


FIGURE 4 — INSTANTANEOUS POWER OUTPUT versus FORWARD CURRENT

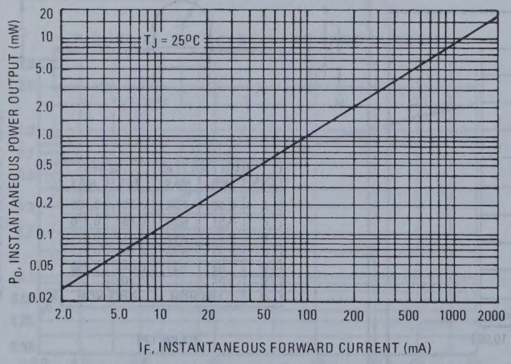
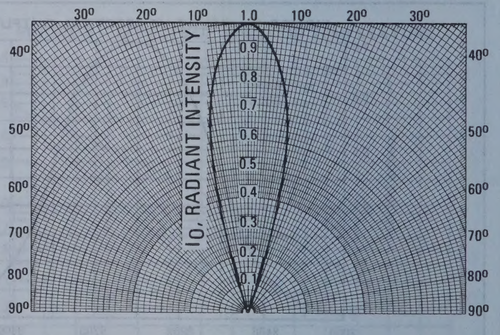


FIGURE 5 — SPATIAL RADIATION PATTERN



Output saturation effects are not evident at currents up to 2 A as shown on Figure 4. However, saturation does occur due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

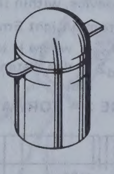
MLED910

INFRARED-EMITTING DIODE

. . . designed for applications requiring high density mounting, high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card and tape readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High Power Output — 150 μW (Typ) @ I_F = 50 mA
- Infrared-Emission — 9000 Å (Typ)
- Low Drive Current — 10 mA for 32 μW (Typ)
- Low Profile Pill Package Allows Printed Circuit Board Assembly
- Sub-Miniature Package for High Density Mounting

INFRARED-EMITTING DIODE
900 nM
PN GALLIUM ARSENIDE
350 MILLIWATTS



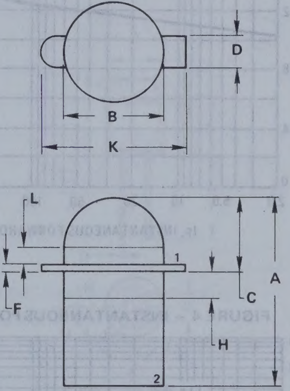
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	150	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	350 3.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +125	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	286	°C/W

(1) Thermal resistance, junction to case is typically 80°C/W. The mounting conditions determine the junction to ambient thermal resistance. For example, when soldered in a copper printed circuit board through a 1/8″ diameter pad on the top to a 1/4″ x 1/4″ pad on the bottom surface, values of 160°C/W will occur. If both pads are 1/8″ in diameter, thermal resistance is typically 250°C/W; the limit of 286°C/W is specified for the latter mounting condition.

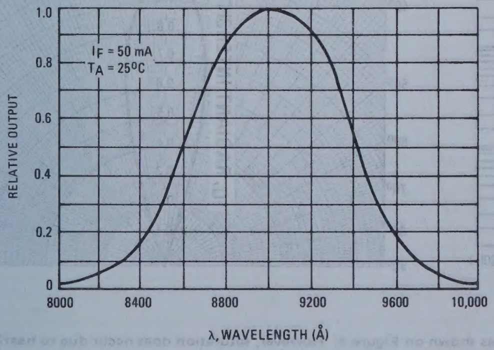


STYLE 2:
TERM 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.79	3.30	0.100	0.130
B	1.47	1.57	0.058	0.062
C	0.71	1.02	0.028	0.040
D	0.41	0.61	0.016	0.024
F	0.13	0.25	0.005	0.010
H	0.48	0.53	0.019	0.021
K	2.11	2.36	0.083	0.093
L	0.20	0.30	0.008	0.012

CASE 81A-05

FIGURE 1 – RELATIVE SPECTRAL OUTPUT



MLED910 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 50 mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Note 1) (I_F = 50 mA)	3, 4	P_o	50	150	–	μW
Radiant Intensity (Note 2) (I_F = 50 mA)	–	I_o	–	0.66	–	mW/steradian
Peak Emission Wavelength	1	λP	–	900	–	nM
Spectral Line Half Width	1	Δλ	–	40	–	nM

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

$H = \frac{I_o}{d^2}$ where H is irradiance in mW/cm², I_o is radiant intensity in mW/steradian; d is distance from LED to the detector in cm.

FIGURE 2 – FORWARD CHARACTERISTICS

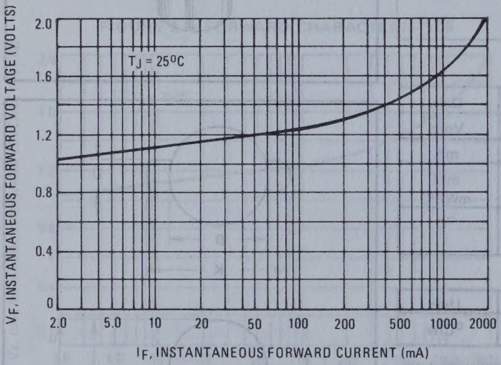


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

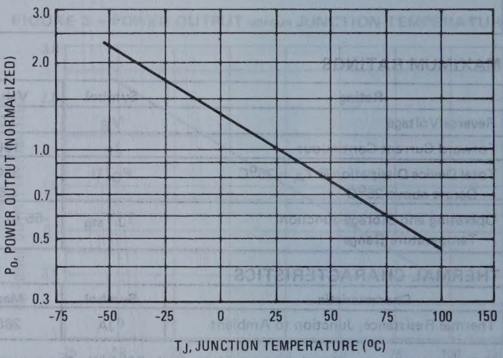


FIGURE 4 – INSTANTANEOUS POWER OUTPUT

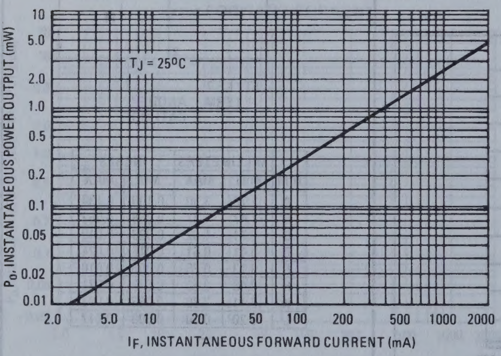
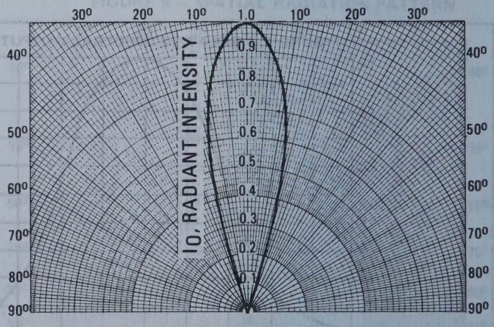


FIGURE 5 – SPATIAL RADIATION PATTERN



Output saturation effects are not evident at currents up to 2 A as shown on Figure 4. However, saturation does occur due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

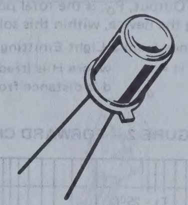
MLED930

INFRARED-EMITTING DIODE

. . . designed for applications requiring high power output, low drive power and very fast response time. This device is used in industrial processing and control, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits. It is spectrally matched for use with silicon detectors.

- High-Power Output — 650 µW (Typ) @ I_F = 100 mA
- Infrared-Emission — 9000 Å (Typ)
- Low Drive Current — 10 mA for 70 µW (Typ)
- Popular TO-18 Type Package for Easy Handling and Mounting
- Hermetic Metal Package for Stability and Reliability

INFRARED-EMITTING DIODE
900 nM
PN GALLIUM ARSENIDE
250 MILLIWATTS



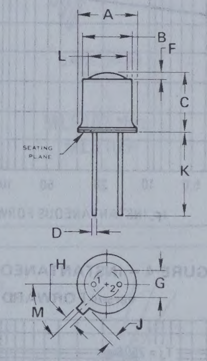
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	150	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	250 2.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +125	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Juntion to Ambient	θ_{JA}	400	°C/W

(1) Printed Circuit Board Mounting

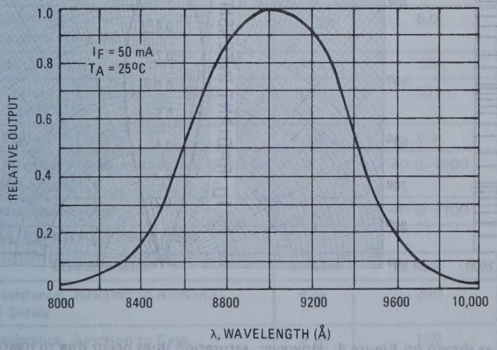


PIN 1. ANODE
PIN 2. CATHODE
PIN 2 INTERNALLY CONNECTED TO CASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	5.08	6.35	0.200	0.250
D	0.41	0.48	0.016	0.019
F	0.51	1.02	0.020	0.040
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
L	3.35	4.01	0.132	0.158
M	45° BSC		45° BSC	

209-01

FIGURE 1 — RELATIVE SPECTRAL OUTPUT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 Megohm)	–	I_R	–	50	–	nA
Reverse Breakdown Voltage (I_R = 100 μA)	–	BV_R	3.0	–	–	Volts
Forward Voltage (I_F = 50 mA)	2	V_F	–	1.2	1.5	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Total Power Output (Note 1) (I_F = 50 mA)	3, 4	P_o	200	650	–	μW
Radiant Intensity (Note 2) (I_F = 100 mA)		I_o	–	1.5	–	mW/steradian
Peak Emission Wavelength	1	λP	–	900	–	nM
Spectral Line Half Width	1	Δλ	–	40	–	nM

NOTE:

1. Power Output, P_o, is the total power radiated by the device into a solid angle of 2π steradians. It is measured by directing all radiation leaving the device, within this solid angle, onto a calibrated silicon solar cell.
2. Irradiance from a Light Emitting Diode (LED) can be calculated by:

$$H = \frac{I_o}{d^2}$$ where H is irradiance in mW/cm^2; I_o is radiant intensity in mW/steradian; d is distance from LED to the detector in cm.

FIGURE 2 – FORWARD CHARACTERISTICS

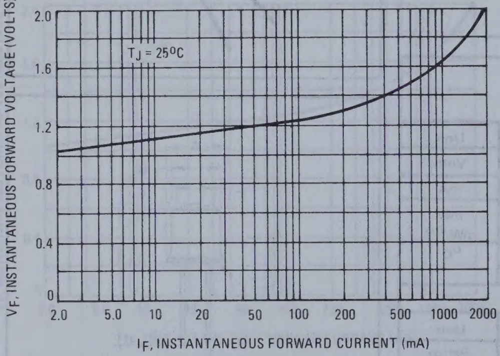


FIGURE 3 – POWER OUTPUT versus JUNCTION TEMPERATURE

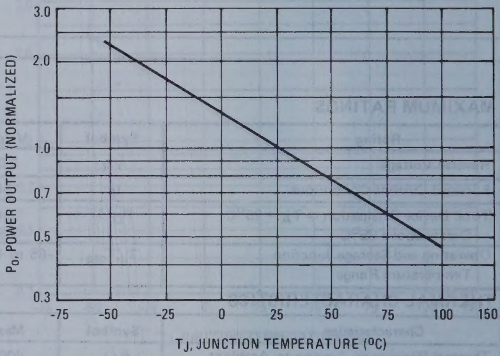


FIGURE 4 – INSTANTANEOUS POWER OUTPUT versus FORWARD CURRENT

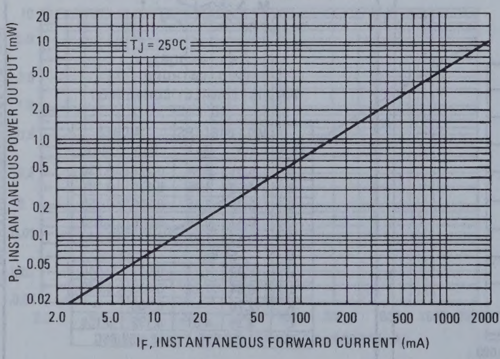
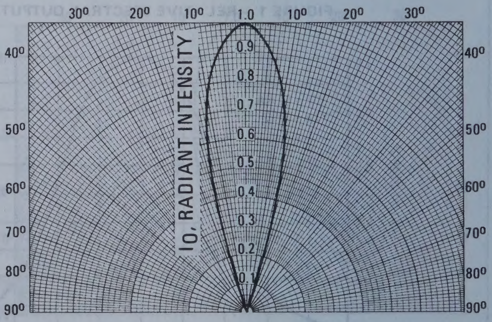


FIGURE 5 – SPATIAL RADIATION PATTERN



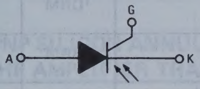
Output saturation effects are not evident at currents up to 2 A as shown on Figure 4. However, saturation does occur due to heating of the semiconductor as indicated by Figure 3. To estimate output level, average junction temperature may be calculated from:

$$T_{J(AV)} = T_A + \theta_{JA} V_F I_F D$$

where D is the duty cycle of the applied current, I_F. Use of the above method should be restricted to drive conditions employing pulses of less than 10 μs duration to avoid errors caused by high peak junction temperatures.

MLS101 thru MLS105 (SILICON)
MLS201 thru MLS205

Advance Information

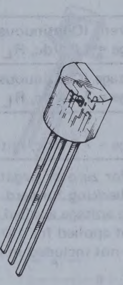


LIGHT SENSITIVE THYRISTORS

. . .Annular PNPN devices designed for applications such as optoelectronic couplers, relay and lamp drivers, small motor controllers, drivers for larger thyristors, and in sensing and detection circuits.

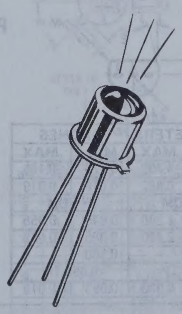
- Sensitive Gate Trigger –
  35 mW/cm^2 (Typ) – MLS101 thru MLS105
  10 mW/cm^2 (Typ) – MLS201 thru MLS205
- Low Reverse and Forward Blocking Current –
  100 μA (Max), T_C = 100°C
- Low Holding Current – 2.0 mA (Max)
- Passivated Surface for Reliability and Uniformity
- Choice of Packages –
  Plastic TO-92 – MLS101 thru MLS105
  Metal TO-18 – MLS201 thru MLS205

LIGHT ACTIVATED SILICON CONTROLLED RECTIFIERS
250, 400 mA RMS
15 thru 200 VOLTS



CASE 29-01
TO-92

MLS101 thru MLS105



CASE 82
TO-18

MLS201 thru MLS205

MAXIMUM RATINGS

Rating	Symbol	MLS101 Series	MLS201 Series	Unit
Peak Reverse Blocking Voltage	V_{RRM}			Volts
MLS101, MLS201		15		
MLS102, MLS202		30		
MLS103, MLS203		60		
MLS104, MLS204		100		
MLS105, MLS205		200		
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	250	400	mA
Peak Forward Surge Current, T_A = 25°C (1/2 cycle, Sine Wave, 60 Hz)	I_{TSM}	5.0		Amp
Average Gate Current – Forward, T_A = 25°C	$I_{GF(AV)}$	25		mA
Peak Gate Current – Forward, T_A = 25°C (300 μs, 120 PPS)	I_{GFM}	500		mA
Peak Gate Voltage – Reverse	V_{GRM}	6.0		Volts
Operating Junction Temperature Range @ Rated V_{RRM} and V_{DRM}(1)	T_J	-40 to +100		°C
Storage Temperature Range	T_{stg}	-40 to +100		°C

THERMAL CHARACTERISTICS

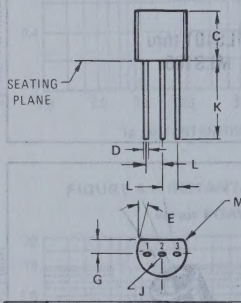
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient MLS101 Series	θ_{JA}	200	°C/W
Thermal Resistance, Junction to Case MLS201 Series	θ_{JC}	150	°C/W

This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (R_{GK} = 15 k Ohms, T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) (T_C = 100°C		V_{DRM}			Volts
	MLS101, MLS201		15	–	
	MLS102, MLS202		30	–	
	MLS103, MLS203		60	–	
	MLS104, MLS204		100	–	
	MLS105, MLS205		200	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_C = 100°C)		I_{DRM}	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_C = 100°C)		I_{RRM}	–	100	μA
Forward "On" Voltage (Note 2)		V_{TM}			Volts
(I_{TM} = 250 mA)	MLS101 thru MLS105		–	1.8	
(I_{TM} = 400 mA)	MLS201 thru MLS205		–	1.7	
Light Sensitivity (V_{AK} = 7.0 V, Tungsten Source @ 2780°K)		H_{ET}			mW/cm²
	MLS101 thru MLS105		–	50	
	MLS201 thru MLS205		–	20	
Gate Trigger Current (Continuous dc) (Note 3) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms, T_C = 25°C)		I_{GT}	–	100	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	T_C = 25°C	V_{GT}	–	0.8	Volts
	T_C = 100°C	V_{GD}	0.1		
Holding Current (Anode Voltage = 7.0 Vdc, initiating current = 20 mA)	T_C = 25°C	I_H	–	2.0	mA

1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Forward current applied for 1.0 ms maximum duration, duty cycle ⩽ 1.0%.
3. R_{GK} current is not included in measurement.

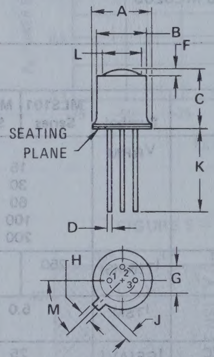


MLS101 thru MLS105

CASE 29-01
TO-92

Pin 1. Gate
2. Anode
3. Cathode

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
C	4.450	4.700	0.175	0.185
D	0.407	0.482	0.016	0.019
E	5° NOM		5° NOM	
G	1.150	1.390	0.045	0.055
J	2.160	2.420	0.085	0.095
K	12.700	–	0.500	–
L	1.270 TP		0.050 TP	
M	0.076	0.330	0.003	0.013



MLS201 thru MLS205

CASE 82
TO-18

Pin 1. Cathode
2. Gate
3. Anode

NOTES:
1. LEADS WITHIN .13 mm (.005) RADIUS OF TRUE POSITION AT SEATING PLANE, AT MAXIMUM MATERIAL CONDITION.
2. PIN 3 INTERNALLY CONNECTED TO CASE.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	5.08	6.35	0.200	0.250
D	0.41	0.48	0.016	0.019
F	0.51	1.02	0.020	0.040
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
L	3.35	4.01	0.132	0.158
M	45° BSC		45° BSC	

MM439 (SILICON)

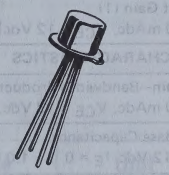
Advance Information

PNP SILICON ANNULAR RF/VHF AMPLIFIER TRANSISTOR

. . . designed for use in RF and VHF amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 15 Vdc (Min) @ I_C = 2.0 mAdc
- High Current-Gain—Bandwidth Product — f_T = 1000 MHz (Typ) @ I_C = 3.0 mAdc
- Low Collector-Base Capacitance — C_{cb} = 0.4 pF (Typ) @ V_{CB} = 12 Vdc
- High Common-Emitter Amplifier Power Gain — G_{PE} = 22 dB (Typ) @ I_C = 3.0 mAdc
- Excellent Electrical Replacement for Germanium Mesa Technology MM5000 Series

PNP SILICON
RF/VHF AMPLIFIER
TRANSISTOR



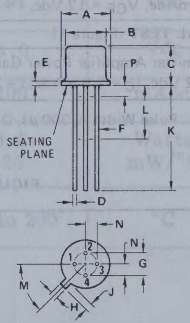
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 1.43	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	700	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	438	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

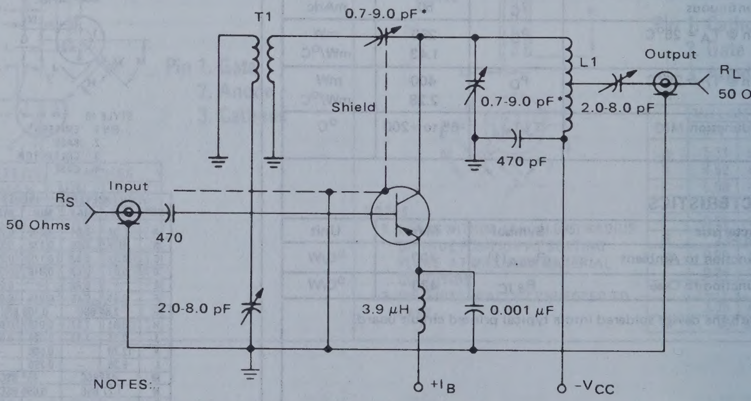
This is advance information on a new introduction, and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 2.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 500 µAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 3.0 mAdc, V_{CE} = 12 Vdc)	h_{FE}	30	50	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (1) (I_C = 3.0 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	800	1000	–	MHz
Collector-Base Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.4	0.6	pF
Collector-Base Time Constant (I_E = 3.0 mAdc, V_{CB} = 12 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	2.9	3.5	ps
Noise Figure (I_C = 3.0 mAdc, V_{CE} = 12 Vdc, f = 200 MHz)	NF	–	2.5	3.5	dB
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12 Vdc, I_C = 3.0 mAdc, f = 200 MHz)	G_{PE}	18	22	–	dB

(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.

FIGURE 1 – 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



NOTES:

L1 ¼ inch inside diameter, ½ inch length, 4 turns #20 solid copper wire, center tapped.

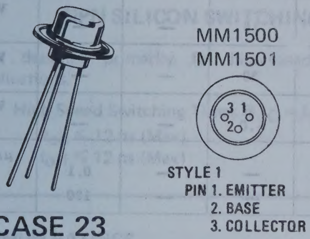
T1 ¼ inch inside diameter, close wound, 3 turns #26 solid copper wire. 1:1 ratio bifiller wound.

* High Quality piston type capacitor.

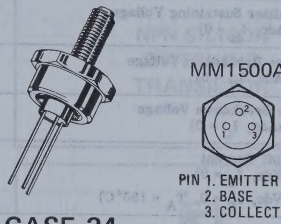
Distance from emitter contact of transistor to ground side of bypass capacitor should be kept minimum.

MM1500, A (SILICON)
MM1501

NPN silicon RF power transistors designed for UHF amplifier, frequency multiplier, and oscillator applications.


MM1500
MM1501
3 1
2
STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 23
(TO-107)


MM1500A
2
1
3
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 24
(TO-102)

MAXIMUM RATINGS ($T_A = 25^oC$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltagee	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)		$BV_{CEO(sus)}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	— —	0.1 100	μAdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM1500, A MM1501	f_T	— —	1500 1000	— —	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	3.2	5.0	pF
Collector-Base Time Constant (I_E = 100 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	MM1500, A MM1501	$r_b'C_c$	— —	7.0 10	— —	ps
FUNCTIONAL TEST						
Power Output, Figure 1 (V_{CB} = 20 Vdc, R_L = 50 ohms, f = 1500 MHz)	MM1500, A MM1501	P_{out}	250 150	— —	— —	mW

FIGURE 1 — POWER OUTPUT TEST CIRCUIT

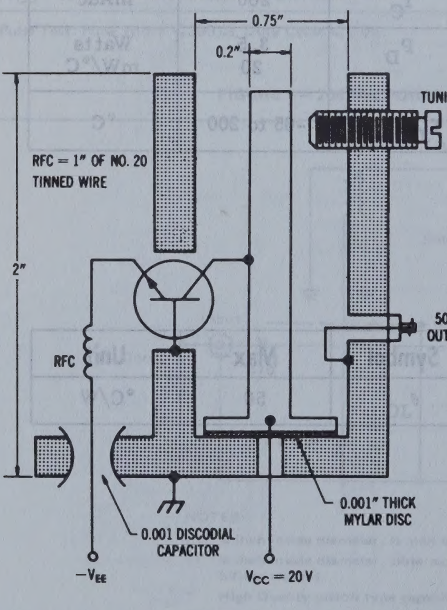
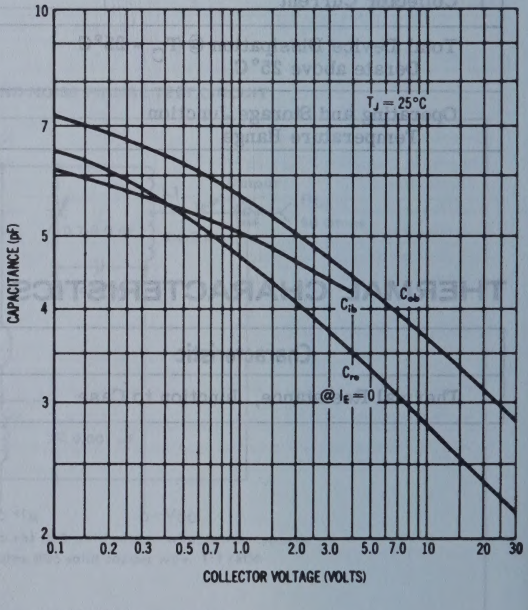

0.75"
0.2"
TUNING
RFC = 1" OF NO. 20 TINNED WIRE
2"
RFC
50 Ω OUTPUT
0.001" THICK MYLAR DISC
0.001 DISCODIAL CAPACITOR
$-V_{EE}$
V_{CC} = 20 V

FIGURE 2 — CAPACITANCES



MM1505 (SILICON)

NPN SILICON SWITCHING TRANSISTOR

. . . designed primarily for high-speed, saturated switching applications.

- High Speed Switching Times @ I_C = 10 mAdc – $t_{on} \leqslant 12$ ns (Max) $t_{off} \leqslant 12$ ns (Max)

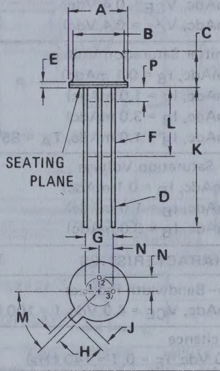
NPN SILICON SWITCHING TRANSISTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}	6.0	Vdc
Collector-Emitter Voltage	V_{CES}	11	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.30 1.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C
Lead Temperature (Soldering, 60 second time limit)	T_L	300	°C

*Indicates JEDEC Registered Data.
(1) applicable from 0.01 mAdc to 10 mAdc (Pulsed).

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR


A
B
C
E
P
L
F
K
SEATING PLANE
D
G
N
N
M
J
H
1
2
3
45°

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	2.92	3.81	0.115	0.150
D	–	0.533	–	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

CASE 27-02
TO-52

All JEDEC dimensions and notes apply

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

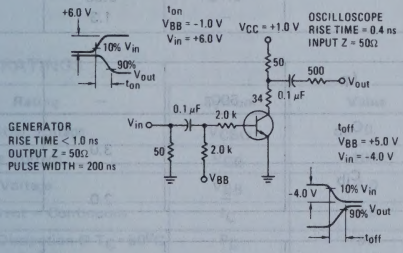
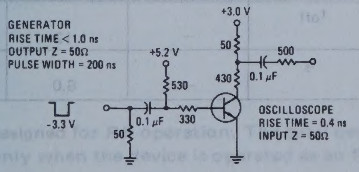

+6.0 V
10% V_{in}
90%
V_{out}
t_{on}
t_{on}
V_{BB} = -1.0 V
V_{in} = +6.0 V
V_{CC} = +1.0 V
OSCILLOSCOPE
RISE TIME = 0.4 ns
INPUT Z = 50Ω
50
500
V_{out}
34
0.1 μF
0.1 μF
2.0 k
V_{in}
GENERATOR
RISE TIME < 1.0 ns
OUTPUT Z = 50Ω
PULSE WIDTH = 200 ns
50
2.0 k
V_{BB}
t_{off}
V_{BB} = +5.0 V
V_{in} = -4.0 V
-4.0 V
10% V_{in}
90%
V_{out}
t_{off}

FIGURE 2 – CHARGE-STORAGE TIME TEST CIRCUIT


GENERATOR
RISE TIME < 1.0 ns
OUTPUT Z = 50Ω
PULSE WIDTH = 200 ns
+3.0 V
+5.2 V
50
500
530
430
0.1 μF
-3.3 V
0.1 μF
330
50
OSCILLOSCOPE
RISE TIME = 0.4 ns
INPUT Z = 50Ω

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	6.0	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	11	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0		Vdc
Collector Cutoff Current (V_{CE} = 11 Vdc, V_{BE} = 0) (V_{CE} = 5.0 Vdc, V_{BE} = 0) (V_{CE} = 5.0 Vdc, V_{BE} = 0, T_A = +85°C)	I_{CES}	– – –	10 0.1 5.0	μAdc
Base Cutoff Current (V_{CE} = 11 Vdc, $V_{EB(off)}$ = 0)	I_{BL}	–	10	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 0.4 Vdc) (I_C = 10 mAdc, V_{CE} = 0.4 Vdc) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	h_{FE}	15 25 15	– 125 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 85°C)	$V_{CE(sat)}$	– – – –	0.25 0.25 0.38 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	0.68 0.75 –	0.85 0.95 1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	f_T	600	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f - 140 kHz)	C_{ib}	–	2.0	pF
SWITCHING TIMES				
Turn-On Time (Figure 1) (V_{CC} = 1.0 Vdc, $V_{BE(off)}$ = 1.0 Vdc, I_C = 10 mAdc, I_{B1} ≈ 2.0 mAdc)	t_{on}	–	12	ns
Turn-Off Time (Figure 1) (V_{CC} = 1.0 Vdc, I_C = 10 mAdc, I_{B1} ≈ I_{B2} ≈ 1.0 mAdc)	t_{off}	–	12	ns
Charge Storage Time (Figure 2) (I_C = I_{B1} ≈ I_{B2} = 5.0 mAdc)	t_s	–	6.0	ns

*Indicates JEDEC Registered Data.

(1) pulse Test: Pulse Length = 300 μs; Duty Cycle ≤ 2.0%)

MM1553 (SILICON)

NPN SILICON RF POWER TRANSISTOR

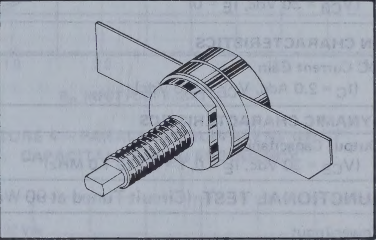
. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 175 MHz.

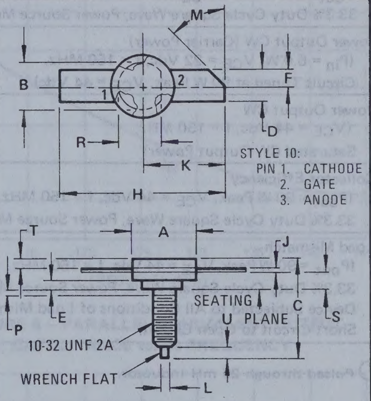
- High Output Power Capability – 90 Watts Peak Output for 13.5 Watts (Max) Input @ f = 150 MHz
- Balanced Emitter Construction to Assure Ruggedness and Resist Transistor Damage Caused by Load Mismatch
- Stripline Packaging for Lower Lead Inductance and Better Broadband Capability

75 W – 150 MHz

RF POWER TRANSISTOR

NPN SILICON





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.45	12.95	0.490	0.510
B	10.41	10.92	0.410	0.430
C	21.21	21.46	0.835	0.845
D	8.51	8.76	0.335	0.345
E	1.78	2.03	0.070	0.080
F	4.19	4.45	0.165	0.175
H	22.86	23.62	0.900	0.930
J	0.10	0.15	0.004	0.006
K	11.43	11.81	0.450	0.465
L	1.65	1.91	0.065	0.075
M	40°	50°	40°	50°
P	–	1.27	–	0.050
R	9.78	10.03	0.385	0.395
S	4.11	4.42	0.162	0.174
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

CASE 145C-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	8.0	Adc
Total Device Dissipation @ $T_C = 50^{\circ}C$ Derate above $50^{\circ}C$	P_D	80 533	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ① (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	70	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	70	85	pF

FUNCTIONAL TEST (Circuit Tuned at 90 Watts Peak, V_{CE} = 44 Vdc and not retuned for 22 Vdc Carrier Power Test)

Characteristic	Symbol	Min	Typ	Max	Unit
Power Input (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	$P_{in(peak)}$	–	11	13.5	Watts
Power Output CW (Carrier Power) (P_{in} = 6.0 W, V_{CE} = 22 Vdc, f = 150 MHz, Circuit Tuned at 90 W Peak, V_{CE} = 44 Vdc)	P_{out}	25	28	–	Watts
Power Output CW (V_{CE} = 44 Vdc, f = 150 MHz, Saturated CW Output Power)	P_{out}	75	–	–	Watts
Collector Efficiency (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	η	50	–	–	%
Load Mismatch (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated. Device Subjected to All Conditions of Load Mismatch from Short-Circuit to Open Circuit)	Less Than 5% Change in Power Readings Before and After Mismatch Tests.				

① Pulsed through 25 mH Inductor.

FIGURE 1 – POWER OUTPUT versus POWER INPUT

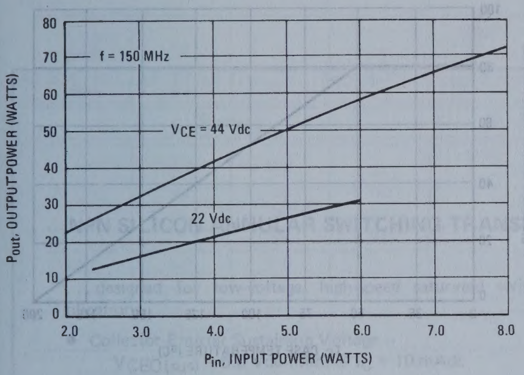


FIGURE 2 – POWER OUTPUT versus POWER INPUT

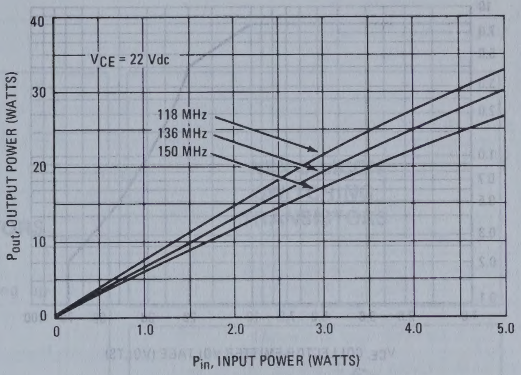


FIGURE 3 – POWER OUTPUT versus COLLECTOR-EMITTER VOLTAGE

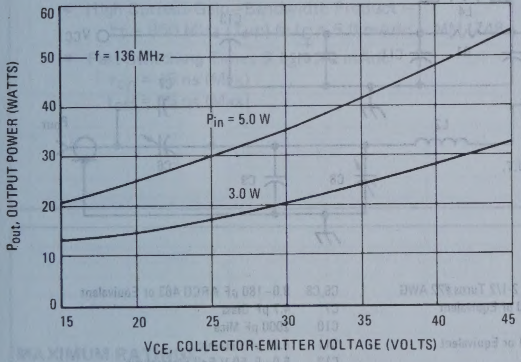


FIGURE 4 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

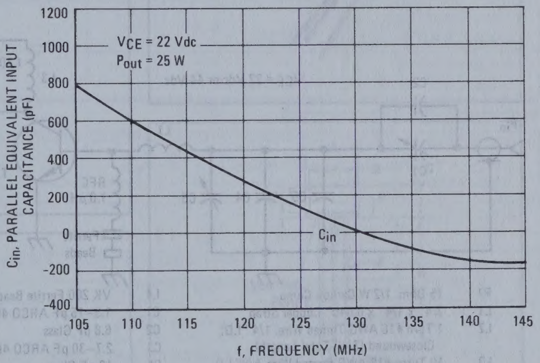


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

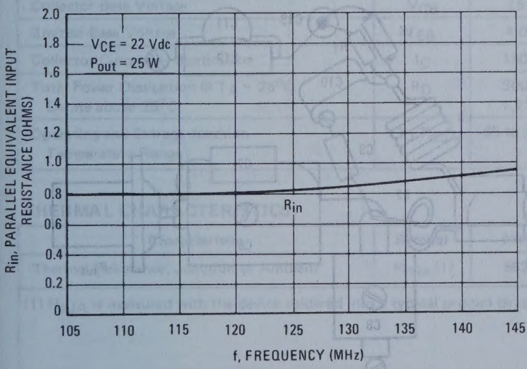


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

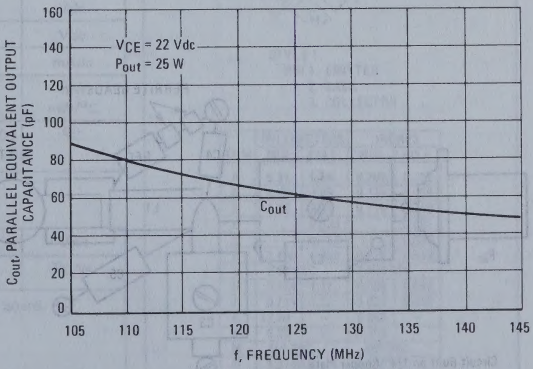


FIGURE 7 – SAFE-OPERATING AREA

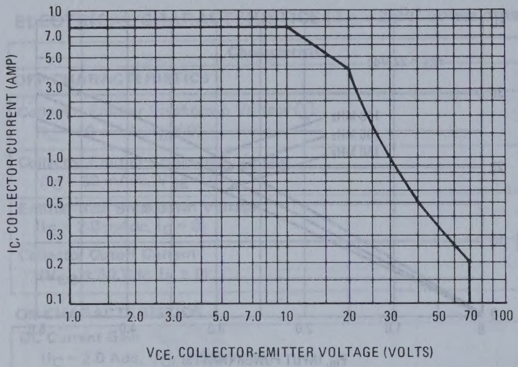


FIGURE 8 – POWER-TEMPERATURE DERATING CURVE

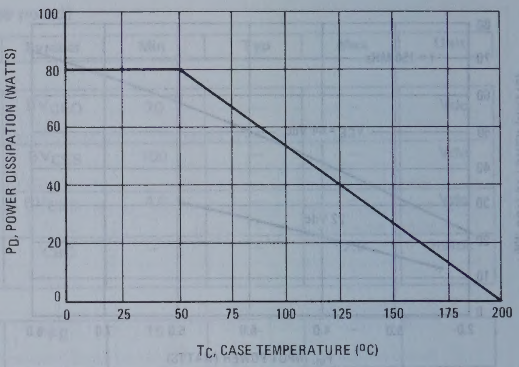
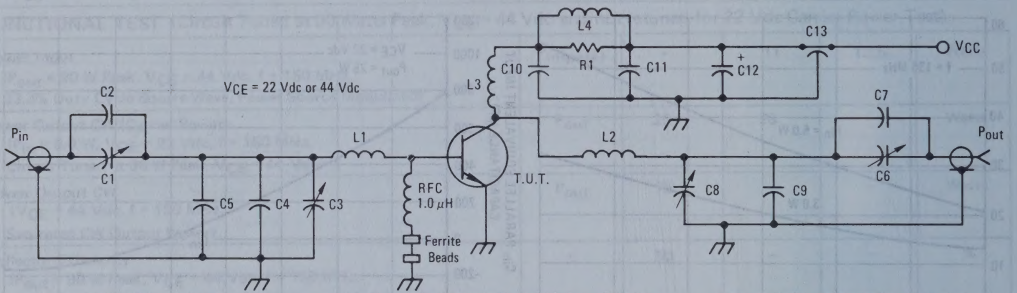
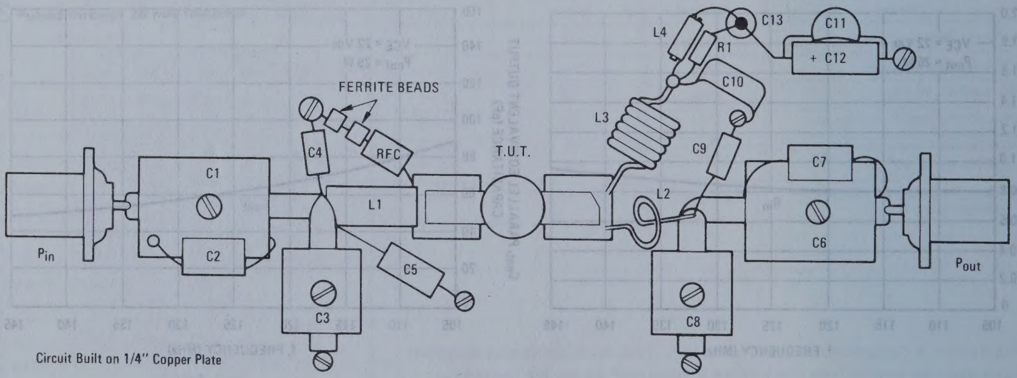


FIGURE 9 – 150 MHz TEST CIRCUIT


L4
C13
R1
V$_{CC}$
C10
C11
+
C12
L3
V$_{CE}$ = 22 Vdc or 44 Vdc
C2
C7
P$_{in}$
L1
L2
P$_{out}$
C1
T.U.T.
C6
RFC
1.0 μH
C8
C9
C5
C4
C3
Ferrite
Beads

R1	15 Ohm, 1/2 W Carbon Comp.
L1	3/4" x 1/4" x 0.040" Copper Strap
L2	1 Turn #16 AWG Tinned Wire, 1/4" I.D. Closewound (3/4" Total Length)
L3	10 Turns #18 AWG Coated Wire, 5/8" I.D. Closewound (1" Total Length)
L4	VK 200 Ferrite Bead, 2-1/2 Turns #22 AWG
C1	1.5–15 pF ARCO 460 or Equivalent
C2	6.8 pF Glass
C3	2.7–30 pF ARCO 461 or Equivalent
C4	12 pF Glass
C5,C9	22 pF Glass
C6,C8	9.0–180 pF ARCO 463 or Equivalent
C7	4.7 pF Glass
C10	2000 pF Mica
C11	0.01 μF Ceramic
C12	5.0 μF, 50 V Foil Electrolytic
C13	1200 pF Ceramic Feed-Thru

FIGURE 10 – 150 MHz TEST CIRCUIT LAYOUT


C13
C11
L4
R1
+ C12
C10
FERRITE BEADS
L3
C4
RFC
T.U.T.
C9
C7
C1
L1
L2
P$_{in}$
C2
C5
C6
P$_{out}$
C3
C8

Circuit Built on 1/4" Copper Plate

MM1748, A (SILICON)

NPN SILICON ANNULAR SWITCHING TRANSISTORS

. . . designed for low-voltage, high-speed saturated switching applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 6.0 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain Specified @ 10 mAdc and 30 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 3.0 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 850 MHz (Typ) @ I_C = 5.0 mAdc — MM1748A
- Fast Switching Times @ I_C = 10 mAdc
  t_{on} = 15 ns (Max)
  t_{off} = 15 ns (Max)

MAXIMUM RATINGS

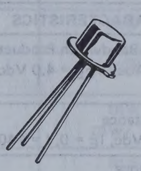
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	6.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

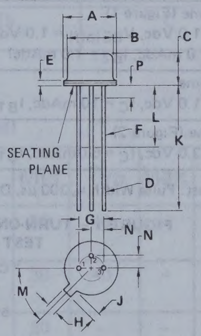
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	583	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON SWITCHING TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	2.92	3.81	0.115	0.150
D	–	0.533	–	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 27
TO-52

MM1748,A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	6.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 5.0 Vdc, I_E = 0)	MM1748	–	–	–	50	nAdc
	MM1748A		–	–	5.0	
(V_{CB} = 5.0 Vdc, I_E = 0, T_A = 150°C)	Both Devices		–	–	5.0	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	MM1748		20	50	120	
	MM1748A		30	55	90	
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)	Both Devices		10	20	–	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)	Both Devices		15	20		
Collector-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.15 mAdc)		$V_{CE(sat)}$	–	0.2	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.15 mAdc)		$V_{BE(sat)}$	0.7	0.78	0.85	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product		f_T				MHz
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	MM1748		600	750	–	
	MM1748A		800	850	–	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	–	2.0	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	–	1.8	2.0	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (Figure 1) (V_{CC} = 1.0 Vdc, $V_{BE(off)}$ = 1.0 Vdc, I_C = 10 mAdc, I_{B1} = 2.0 mAdc, I_{B2} = 1.0 mAdc)		t_{on}	–	12	15	ns
Turn-Off Time (V_{CC} = 1.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)		t_{off}	–	12	15	ns
Storage Time (Figure 2) (V_{CC} = 3.0 Vdc, I_C = 5.0mAdc, I_{B1} = I_{B2} = 5.0 mAdc)		t_s	–	4.0	6.0	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIMES TEST CIRCUIT

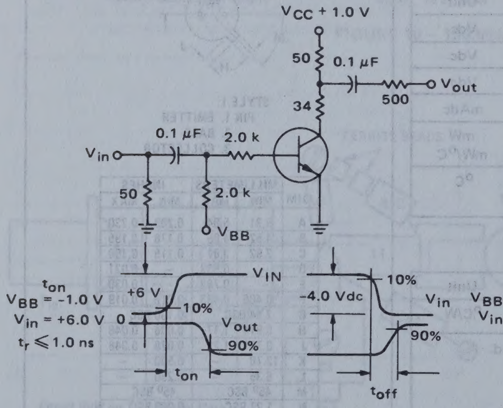
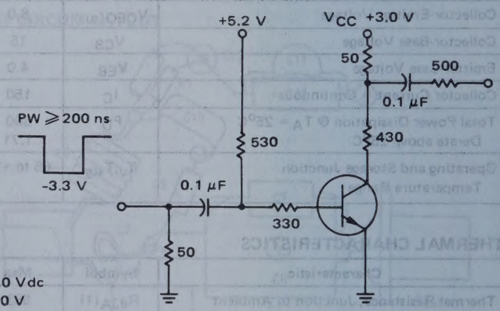

V_{CC} + 1.0 V
50
0.1 μF
500
V_{out}
34
0.1 μF
2.0 k
V_{in}
50
2.0 k
V_{BB}
t_{on}
V_{BB} = -1.0 V
V_{in} = +6.0 V
t_r ≤1.0 ns
+6 V
0
10%
V_{IN}
V_{out}
90%
t_{on}
-4.0 Vdc
10%
V_{in}
t_{off}
V_{BB} = +5.0 Vdc
V_{in} = -4.0 V
90%
t_{off}

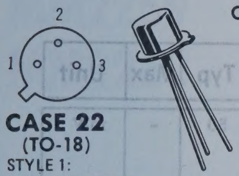
FIGURE 2 – STORAGE TIME TEST CIRCUIT


+5.2 V
V_{CC} +3.0 V
50
500
0.1 μF
PW ≥200 ns
-3.3 V
530
430
0.1 μF
330
50

MM1803 (SILICON)

For Specifications, See 2N3137 Data, Volume I.

MM1941 (SILICON)



Collector connected to case

NPN silicon annular transistor for high-frequency power oscillator, multiplier and driver applications.

CASE 22
(TO-18)
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Base Current	I_B	30	mAdc
Collector Current - Continuous	I_C	200	mAdc
Input Power	P_{in}	100	mW
Output Power	P_{out}	250	mW
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D*	600 4.0	mW mW/°C
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	300 2.0	mW mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

*See Safe Area Curve

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter (1) Sustain Voltage	$V_{CES(sus)}$	I_C = 15 mA, R_{BE} = 0	30	40	-	Vdc
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	30	40	-	Vdc
Collector Emitter-Open Base Sustain Voltage (1)	$BV_{CEO(sus)}$	I_C = 15 mA, I_B = 0	20	-	-	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0 V_{CB} = 15 Vdc, I_E = 0, T_C = 100°C	- -	0.01 -	0.1 25	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	-	0.1	10	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10 Vdc	25	50	-	-
AC Current Gain	$\lvert h_{fe}\rvert$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 100 mc	6.0	8.0	-	-
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz	-	-	2.5	pF
Power Output	P_{out}	P_{in} = 20 mW max, f = 175 MHz	100	-	-	mW
Power Gain	G_e	V_{CC} = 13.6 Vdc, $I_{C(max)}$ = 25 mA	7.0	9.0	-	dB

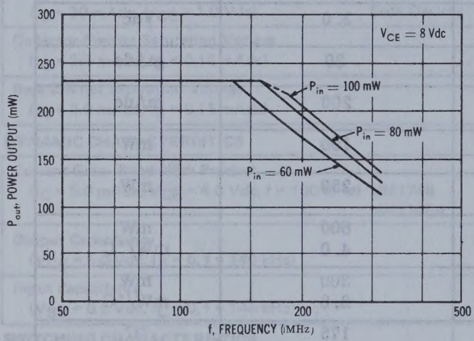
(1) Pulse Test: PW = 100 μs; DC = 2%

ELECTRICAL CHARACTERISTICS (continued)

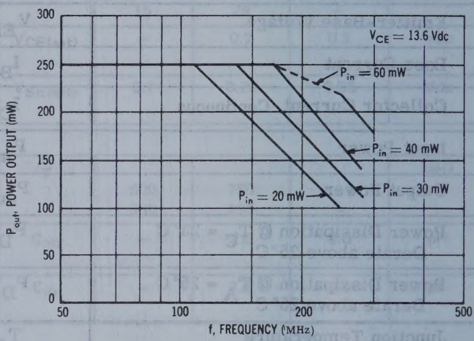
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Output (Oscillator)	P_{out}	f = 80 MHz, V_{CC} = 13.6 Vdc, $I_{C(typ)}$ = 20 mAdc	-	50	-	mW
Power Gain (Multiplier)	G_e	f_{in} = 80 MHz, f_{out} = 240 MHz V_{CC} = 13.6 Vdc, $P_{out} \approx$ 30 mW $I_{C(typ)}$ = 25 mAdc	-	3.0	-	dB

*Pulse Test: PW = 100 μs; DC = 2%

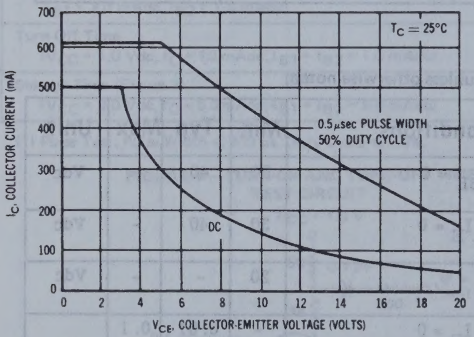
POWER OUTPUT versus FREQUENCY



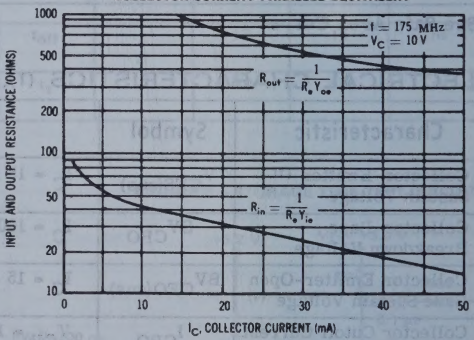
POWER OUTPUT versus FREQUENCY



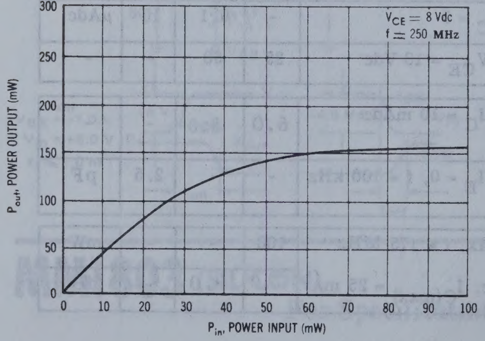
SAFE OPERATING AREA



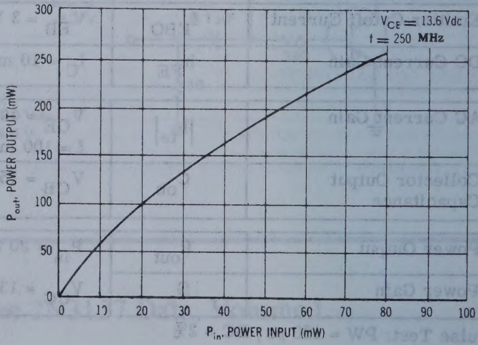
INPUT AND OUTPUT IMPEDANCE versus
COLLECTOR CURRENT PARALLEL EQUIVALENT



POWER OUTPUT CHARACTERISTICS



POWER OUTPUT CHARACTERISTICS



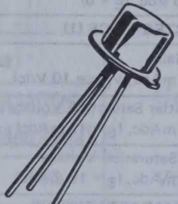
MM2005-2 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in general-purpose amplifier and switching applications.

- Electrically Similar to 2N2906, 2N2907.

PNP SILICON AMPLIFIER TRANSISTOR



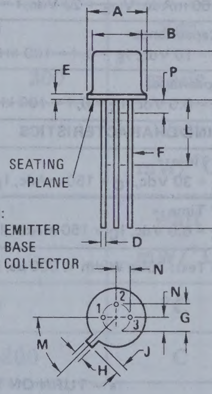
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.28	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.4 8.0	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	438	^oC/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	^oC/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

<table>
<tr><th rowspan="2">DIM</th><th colspan="2">MILLIMETERS</th><th colspan="2">INCHES</th></tr>
<tr><th>MIN</th><th>MAX</th><th>MIN</th><th>MAX</th></tr>
<tr><td>A</td><td>5.31</td><td>5.84</td><td>0.209</td><td>0.230</td></tr>
<tr><td>B</td><td>4.52</td><td>4.95</td><td>0.178</td><td>0.195</td></tr>
<tr><td>C</td><td>4.32</td><td>5.33</td><td>0.170</td><td>0.210</td></tr>
<tr><td>D</td><td>0.406</td><td>0.533</td><td>0.016</td><td>0.021</td></tr>
<tr><td>E</td><td>–</td><td>0.762</td><td>–</td><td>0.030</td></tr>
<tr><td>F</td><td>0.406</td><td>0.483</td><td>0.016</td><td>0.019</td></tr>
<tr><td>G</td><td colspan="2">2.54 BSC</td><td colspan="2">0.100 BSC</td></tr>
<tr><td>H</td><td>0.914</td><td>1.17</td><td>0.036</td><td>0.046</td></tr>
<tr><td>J</td><td>0.711</td><td>1.22</td><td>0.028</td><td>0.048</td></tr>
<tr><td>K</td><td>12.70</td><td>–</td><td>0.500</td><td>–</td></tr>
<tr><td>L</td><td>6.35</td><td>–</td><td>0.250</td><td>–</td></tr>
<tr><td>M</td><td colspan="2">45° BSC</td><td colspan="2">45° BSC</td></tr>
<tr><td>N</td><td colspan="2">1.27 BSC</td><td colspan="2">0.050 BSC</td></tr>
<tr><td>P</td><td>–</td><td>1.27</td><td>–</td><td>0.050</td></tr>
</table>

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	200	400	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.3	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.7	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	–	300	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	6.0	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	20	–	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1a)	t_{on}	–	20	45	μs
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 1b)	t_{off}	–	85	100	μs

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

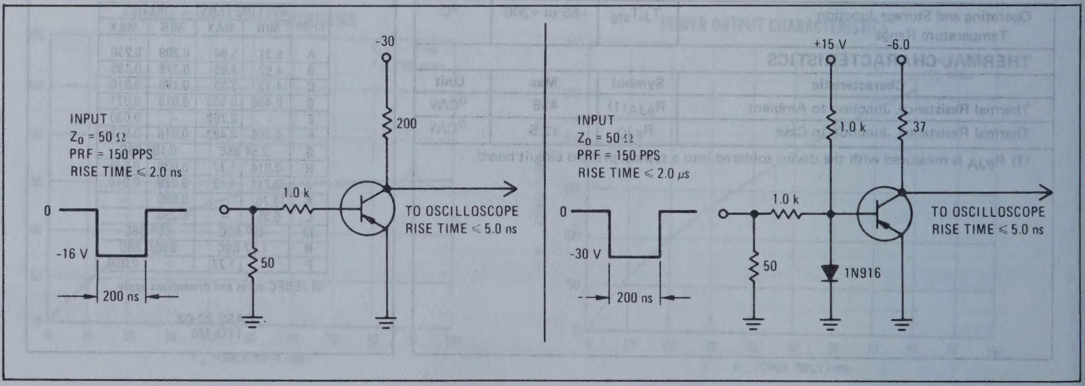

-30
200
INPUT
Z0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 ns
0
-16 V
200 ns
1.0 k
50
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns
+15 V
-6.0
1.0 k
37
INPUT
Z0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 μs
0
-30 V
200 ns
1.0 k
50
1N916
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

1a – TURN-ON TIME

1b – TURN-OFF TIME

MM2258 (SILICON)
MM2259
MM2260

CASE 31
(TO-5)

Collector connected to case

NPN silicon transistors designed for video output circuitry in transistorized television receivers.

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MM2258	MM2259 MM2260	
Collector-Base Voltage	V_{CB}	120	175	Vdc
Collector-Emitter Voltage	V_{CEO}	120	175	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current –Continuous	I_C	500	300	mAdc
Total Power Dissipation @ $T_A = 25°C$ Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derating Factor Above 25°C	P_D	5.0 28.6		Watt mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	— —	0.050 50	µAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}	—	—	25	nAdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0) MM2258 MM2259, MM2260	BV_{CBO}	120 175	— —	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) MM2258 MM2259, MM2260	BV_{CEO}*	120 175	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc
Collector-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	—	—	1.0	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) MM2259 MM2258, MM2260 (I_C = 10 mAdc, V_{CE} = 10 Vdc) MM2259 MM2258, MM2260 (I_C = 50 mAdc, V_{CE} = 10 Vdc) MM2259 MM2258, MM2260	h_{FE}	25 50 35 50 35 50	— — — — — —	— — — — — —	—
Output Capacitance MM2258 (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz) MM2259, MM2260	C_{ob}	— —	— —	9.0 8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	—	80	pF
Feedback (Miller) Capacitance (V_{CB} = 25 Vdc, I_C = 10 mAdc) MM2258 MM2259, MM2260	C_{cb}	— —	4.2 3.0	5.0 4.5	pF
Small Signal Current Gain (V_{CE} = 25 Vdc, I_C = 20 mAdc, f = 100 MHz)	$\|h_{fe}\|$	1.5	—	—	—

*Pulse Test: PW ≤ 300 µs, duty cycle ≤ 2%

FIGURE 1 — DC CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

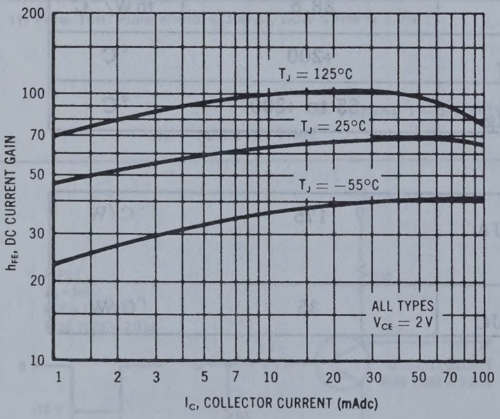
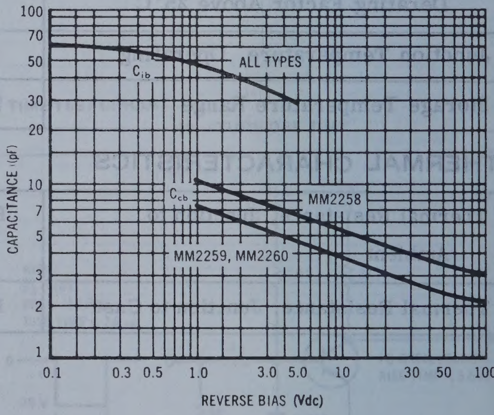


FIGURE 2 — JUNCTION CAPACITANCE VARIATIONS



SMALL SIGNAL h PARAMETER CHARACTERISTICS
(V_{CE} = 10 V, T_A = 25°C, f = 1 kHz)

FIGURE 3 — CURRENT GAIN

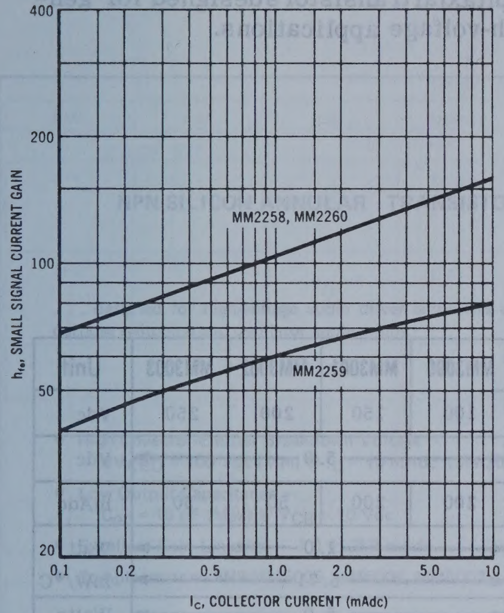


FIGURE 4 — OUTPUT ADMITTANCE

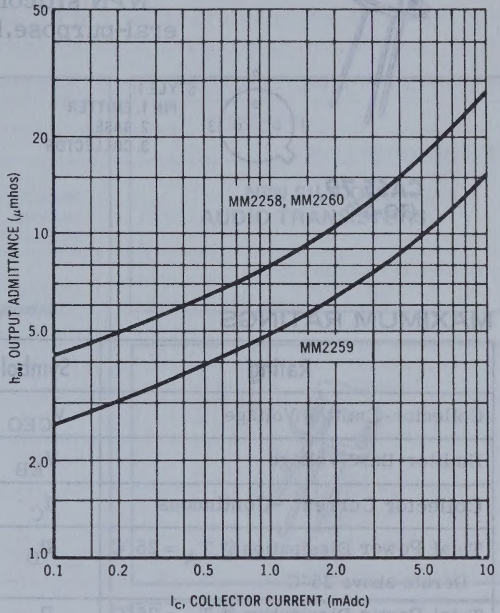


FIGURE 5 — INPUT IMPEDANCE

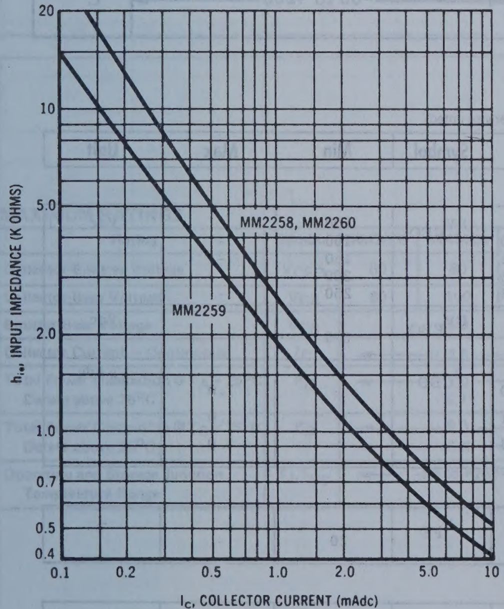
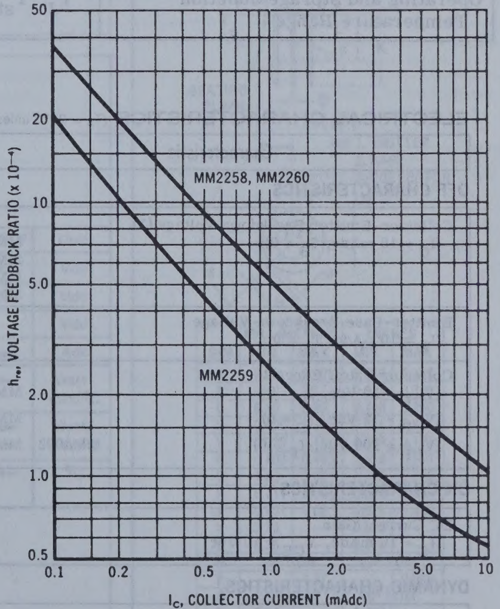
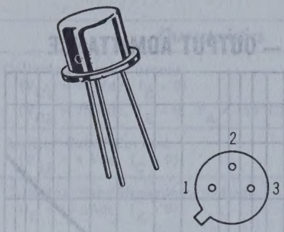


FIGURE 6 — VOLTAGE FEEDBACK RATIO



MM3000 thru MM3003 (SILICON)

NPN silicon epitaxial transistors designed for general-purpose, high-voltage applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)

MAXIMUM RATINGS

Rating	Symbol	MM3000	MM3001	MM3002	MM3003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →				Vdc
Collector Current –Continuous	I_C	200	200	50	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 1.0 → ← 5.71 →				Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 5.0 → ← 28.6 →				Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MM3000 MM3001 MM3002 MM3003	BV_{CEO}	100 100 150 200 250	- - - -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0)	MM3000 MM3001 MM3002, MM3003	I_{CBO}	- - -	1.0 1.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	-	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM3000, MM3001 MM3002, MM3003	C_{ob}	- -	7.0 15	pF

(1) Pulse Test: Pulse Width≤300μs, Duty Cycle 2.0 %

MM3005 (SILICON)
MM3006
MM3007

NPN SILICON ANNULAR TRANSISTORS

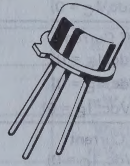
. . . designed for high-voltage audio driver amplifiers and general-purpose switching and oscillator applications.

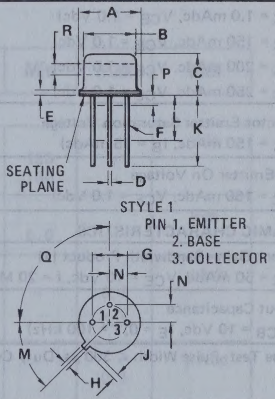
- High Collector-Emitter Breakdown Voltage – $BV_{CEO} = 100$ Vdc (Min) @ $I_C = 10$ mAdc (MM3007)
- Low Output Capacitance – $C_{ob} = 15$ pF (Max) @ $V_{CB} = 10$ Vdc
- Excellent Gain Linearity – 1.0 to 250 mAdc
- Complements to PNP MM5005, MM5006, MM5007

MAXIMUM RATINGS

Rating	Symbol	MM3005	MM3006	MM3007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}		5.0		Vdc
Collector Current – Continuous	I_C		← 2.5 →		Adc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D		← 1.0 → 5.71		Watt mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D		← 8.0 → ← 45.6 →		Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}		← -65 to +200 →		^oC

NPN SILICON AUDIO TRANSISTORS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

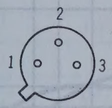
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MM3005	BV_{CEO}	60	–	Vdc
	MM3006		80	–	
	MM3007		100	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM3005	BV_{CBO}	80	–	Vdc
	MM3006		100	–	
	MM3007		120	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	MM3005	I_{CBO}	–	100	nAdc
(V_{CB} = 80 Vdc, I_E = 0)	MM3006		–	100	
(V_{CB} = 100 Vdc, I_E = 0)	MM3007		–	100	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	All Types	h_{FE}	40	–	–
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	MM3005		50	250	
(I_C = 200 mAdc, V_{CE} = 1.0 Vdc)	MM3006		50	250	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	MM3007		50	250	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.35	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	0.60	0.75	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	15	pF

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

MM3008 (SILICON)
MM3009

High-voltage NPN silicon transistors designed for video output circuitry in transistorized television receivers.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	MM3008	MM3009	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	400		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) MM3008 MM3009	BV_{CEO}*	120 180	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc I_C = 0)	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) MM3008 (V_{CB} = 180 Vdc, I_E = 0) MM3009	I_{CBO}	- -	0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}		0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30 40 30	- - -	-
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	-	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	20	pF

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — CURRENT GAIN

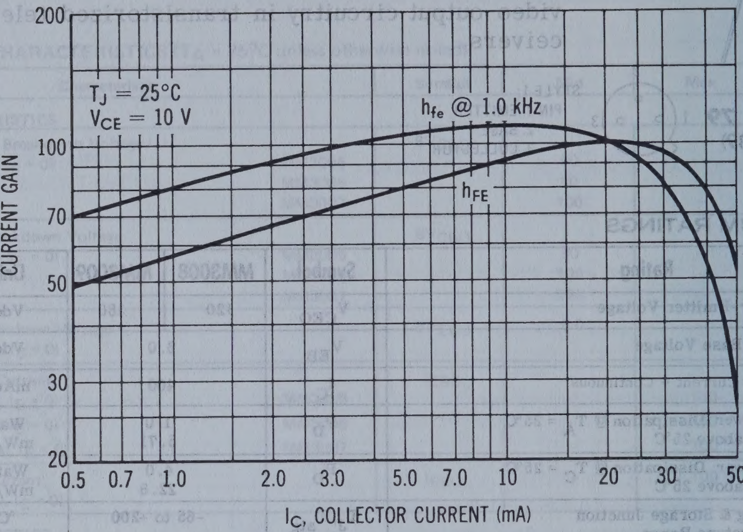
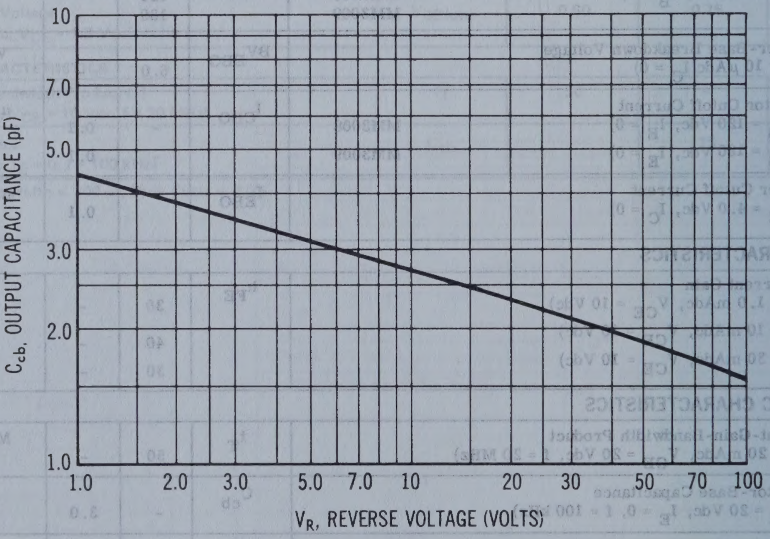


FIGURE 2 — CAPACITANCE



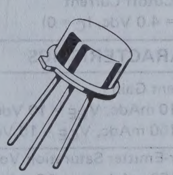
MM3053 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for medium current, medium power amplifier and switching applications.

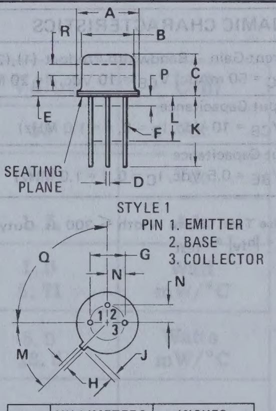
- High Collector-Emitter Breakdown Voltage
  BV_{CEO} = 50 Vdc (Min)
- Similar to 2N3053 in an easy to handle TO-39 Package
- Collector Current — Continuous
  I_C = 1.0 Adc

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.72	Watt $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.
CASE 79-02
TO-39

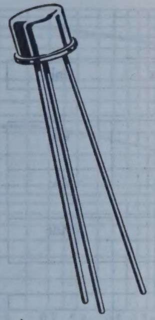
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_C = 0)	BV_{CBO}	80	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (1)	h_{FE}	 35 40	 – 300	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (1),(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	80	pF

(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

MM3726 (SILICON)



Collector connected to case

CASE 31
(TO-5)

PNP silicon annular transistor designed for medium-current, high-speed saturated switching and core driver applications, and for complementary circuitry with NPN type MM3725.

MAXIMUM RATINGS ($T_A = 25^\circ C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Power Dissipation @ $T_A = 25^\circ C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Power Dissipation @ $T_C = 25^\circ C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	—	BV_{CEO}	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	—	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	—	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain	9	h_{FE}			—
(I_C = 500 mAdc, V_{CE} = 2 Vdc)			30	120	
(I_C = 1 Adc, V_{CE} = 5 Vdc)			15	—	
Collector-Emitter Saturation Voltage	10, 11	$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.6	
(I_C = 1 Adc, I_B = 100 mAdc)			—	1.2	
Base-Emitter Saturation Voltage	11	$V_{BE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	1.1	
(I_C = 1 Adc, I_B = 100 mAdc)			—	1.3	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	—	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, emitter guarded)	3	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)	3	C_{eb}	—	80	pF
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	1, 5, 6	t_{on}	—	30	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	2, 7, 8	t_{off}	—	90	ns
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc, I_C = 1 Adc, I_{B1} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	1, 5, 6	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1 Adc, I_{B1} = I_{B2} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	2, 7, 8	t_{off}	—	60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

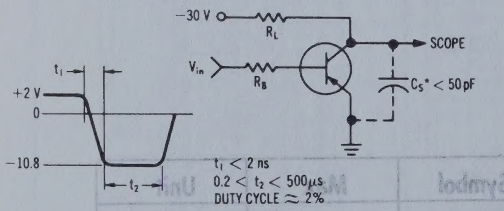
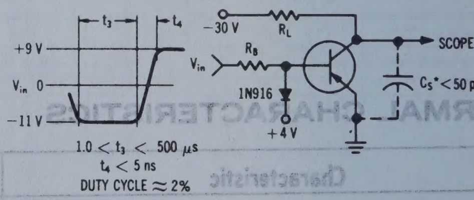


FIGURE 2 — TURN-OFF TIME



*TOTAL SHUNT CAPACITANCE OF TEST JIG, CONNECTORS, AND OSCILLOSCOPE.

TRANSIENT CHARACTERISTICS

——— 25°C   - - - 150°C

FIGURE 3 — CAPACITANCES

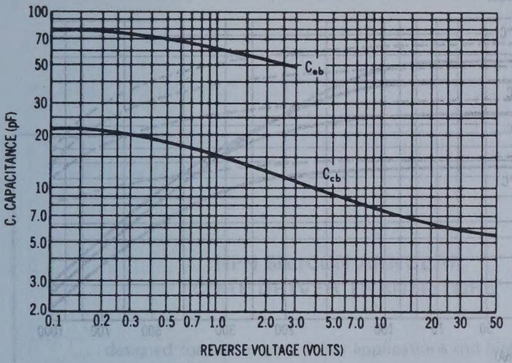


FIGURE 4 — CHARGE DATA

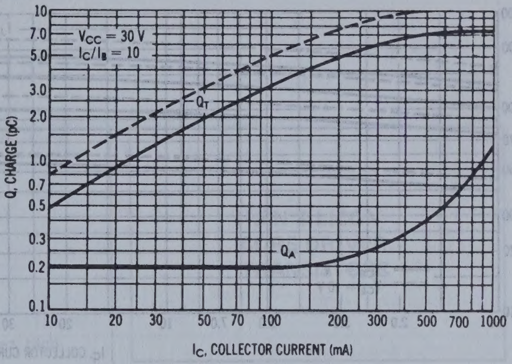


FIGURE 5 — TURN-ON TIME

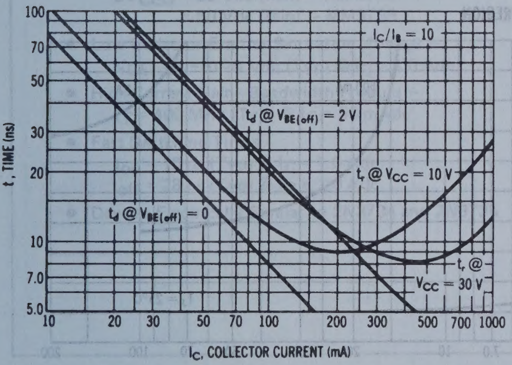


FIGURE 6 — RISE TIME

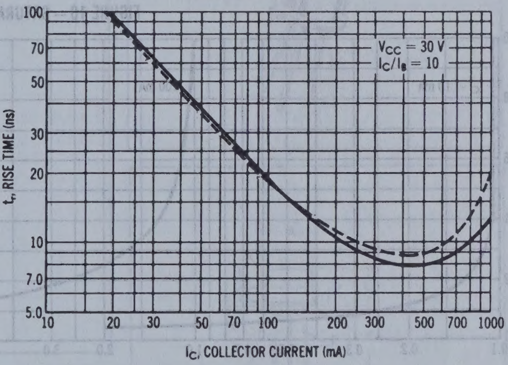


FIGURE 7 — STORAGE TIME

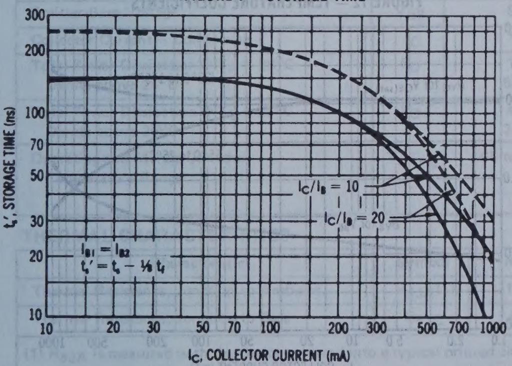
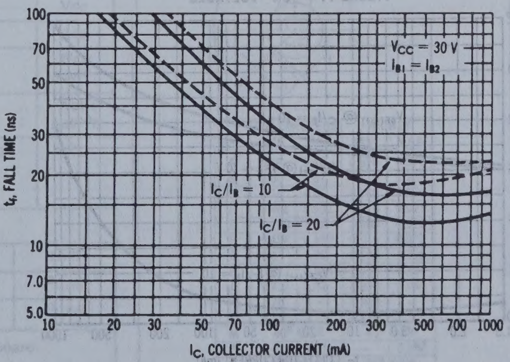


FIGURE 8 — FALL TIME



STATIC CHARACTERISTICS

FIGURE 9 — CURRENT GAIN

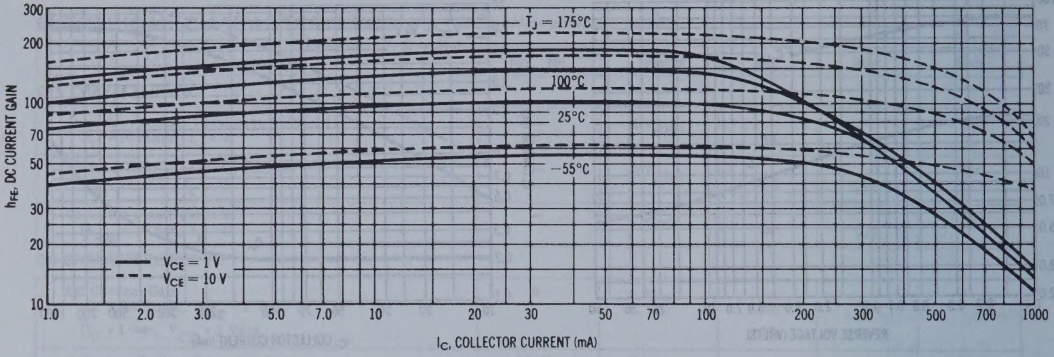


FIGURE 10 — SATURATION REGION

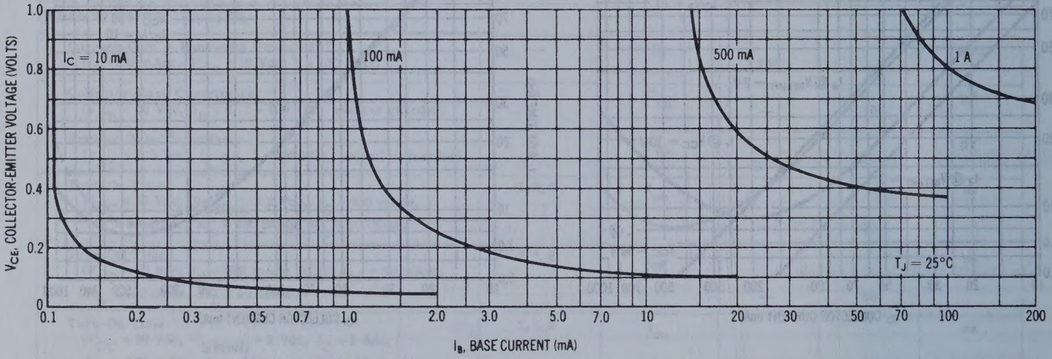


FIGURE 11 — "ON" VOLTAGES

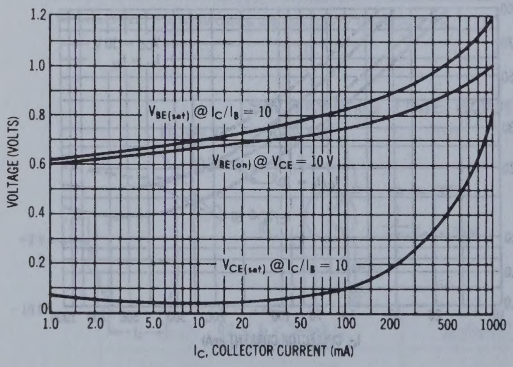
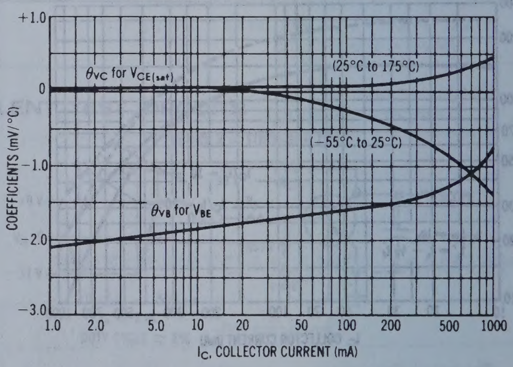


FIGURE 12 — TEMPERATURE COEFFICIENTS



MM3734 (SILICON)
MM3735

NPN SILICON ANNULAR CORE DRIVER TRANSISTORS

. . . designed for use in core driver applications and high speed, high-current switching applications.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 30 Vdc (Min) — MM3734
  = 50 Vdc (Min) — MM3735
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.29 Vdc (Typ) @ I_C = 1.0 Adc
- High Current-Gain—Bandwidth Product —
  f_T = 400 MHz (Typ) @ I_C = 50 mAdc
- Fast Switching Times —
  t_{on} = 16 ns (Typ) @ I_C = 1.0 Adc
  t_{off} = 28 ns (Typ) @ I_C = 1.0 Adc
- Devices Electrically Similar to 2N3734 and 2N3735

MAXIMUM RATINGS

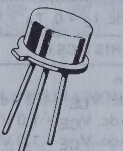
Rating	Symbol	MM3734	MM3735	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CB}	50	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

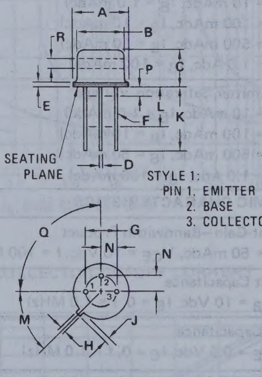
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON CORE DRIVER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	MM3734		30	–	–	
	MM3735		50	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 10 μAdc, I_E = 0)	MM3734		50	–	–	
	MM3735		75	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 30 Vdc, I_E = 0)			–	–	500	nAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)			–	–	75	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			40	85	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			50	100	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			35	65	–	
(I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)	MM3734		25	35	100	
	MM3735		20	35	100	
(I_C = 1.5 Adc, V_{CE} = 5.0 Vdc)	MM3734		25	30	–	
	MM3735		20	30	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.15	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)			–	0.16	0.30	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.20	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	0.29	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.65	0.8	
(I_C = 100 mAdc, I_B = 10 mAdc)			–	0.75	0.9	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.86	1.2	
(I_C = 1.0 Adc, I_B = 100 mAdc)			0.8	0.94	1.4	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	400	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	7.3	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	72	90	pF
SWITCHING CHARACTERISTICS (Figure 11)						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc)		t_{on}	–	16	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)		t_{off}	–	28	60	ns

(1) Pulse Width: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA

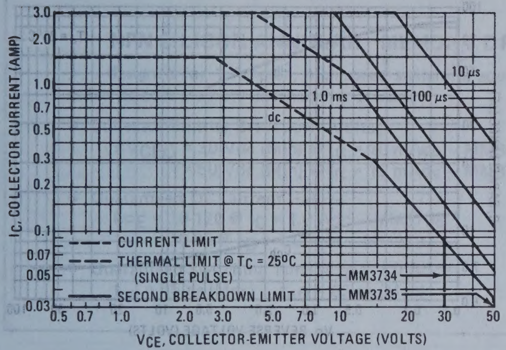


FIGURE 2 – DC CURRENT GAIN

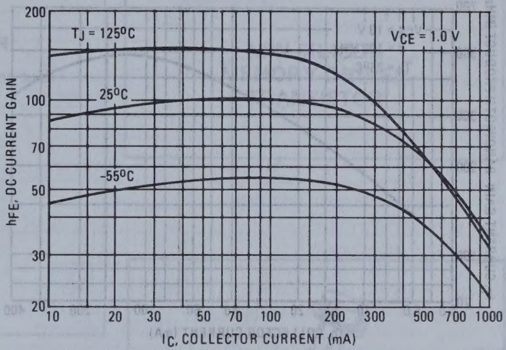


FIGURE 3 – "ON" VOLTAGES

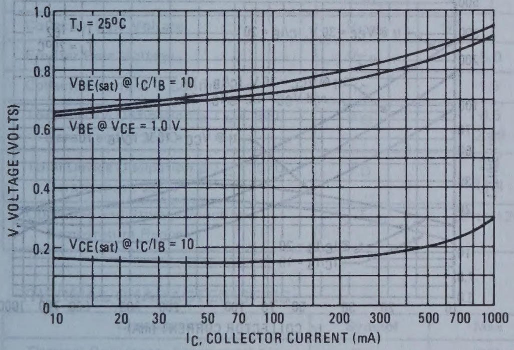


FIGURE 4 – COLLECTOR SATURATION REGION

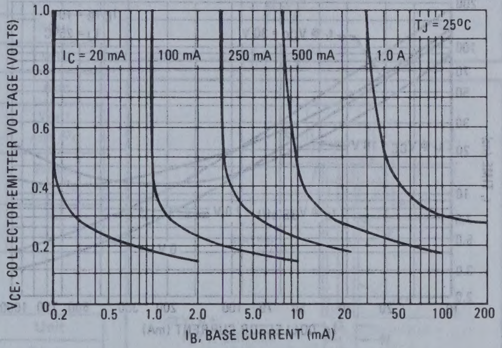


FIGURE 5 – TEMPERATURE COEFFICIENT

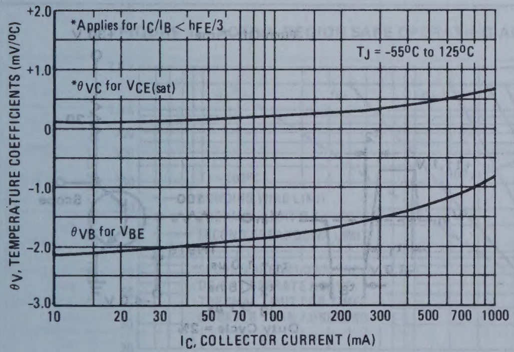
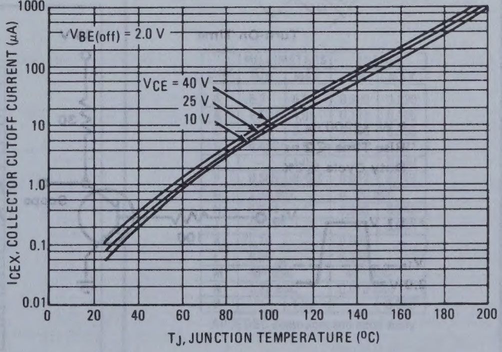


FIGURE 6 – COLLECTOR CUTOFF CURRENT



DYNAMIC CHARACTERISTICS

FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

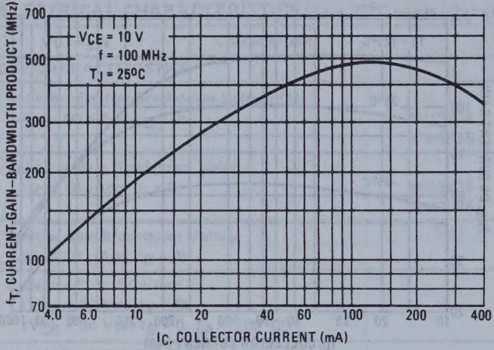


FIGURE 8 – CAPACITANCE

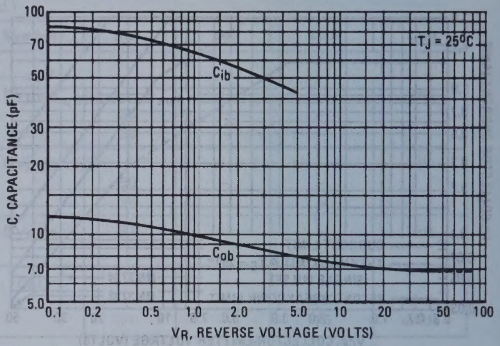


FIGURE 9 – TURN-ON TIME

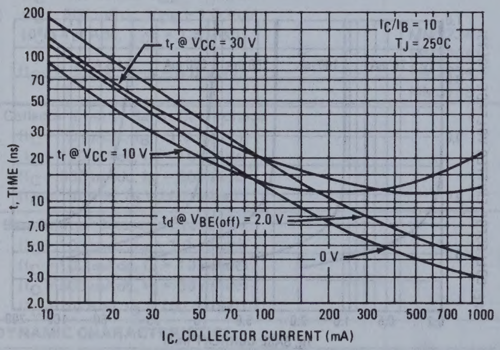


FIGURE 10 – TURN-OFF TIME

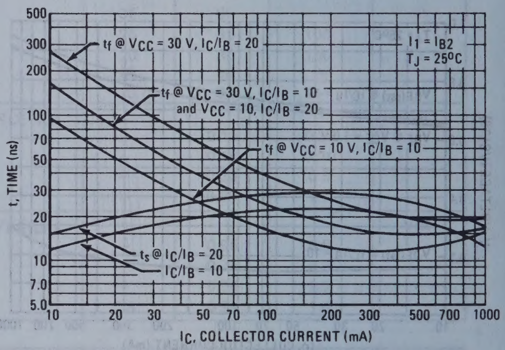
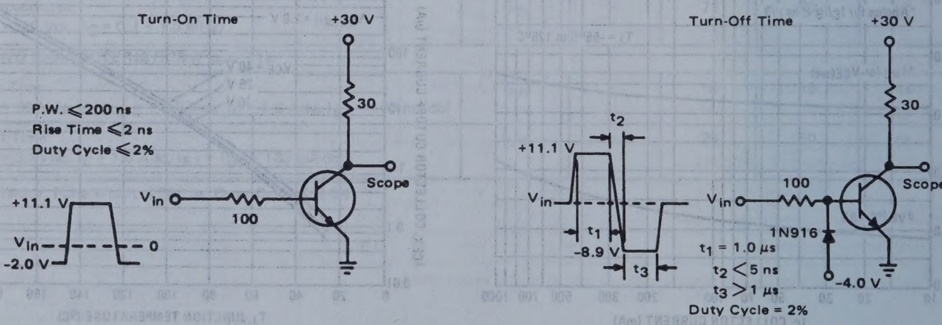


FIGURE 11 – SWITCHING TIME TEST CIRCUITS


Turn-On Time
+30 V
30
P.W. ≤200 ns
Rise Time ≤2 ns
Duty Cycle ≤2%
+11.1 V
V_{in}
0
-2.0 V
V_{in}
100
Scope
Turn-Off Time
+30 V
30
t_2
+11.1 V
V_{in}
t_1
-8.9 V
t_3
V_{in}
100
Scope
1N916
t_1 = 1.0 µs
t_2 < 5 ns
t_3 > 1 µs
Duty Cycle = 2%
-4.0 V

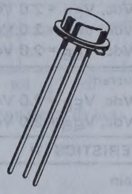
MM3736, MM3737 (SILICON)

NPN SILICON ANNULAR MEMORY DRIVER

. . . designed for 1 Ampere, high-speed switching applications such as ferrite core memory and hammer drivers.

- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 30 Vdc (Min) @ I_C = 10 mAdc – MM3736
  = 50 Vdc (Min) @ I_C = 10 mAdc – MM3737
- Guaranteed DC Current Gain –
  h_{FE} = 30-120 @ I_C = 1.0 Adc – MM3736
  = 20-80 @ I_C = 1.0 Adc – MM3737
- Guaranteed Switching Time @ I_C = 1.0 Adc –
  t_{on} = 45 ns (Max) t_{off} = 65 ns (Max)

NPN SILICON MEMORY DRIVER TRANSISTOR



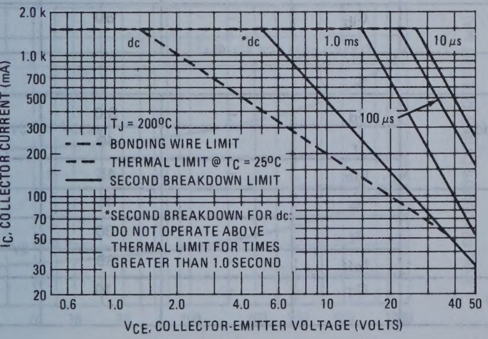
*MAXIMUM RATINGS

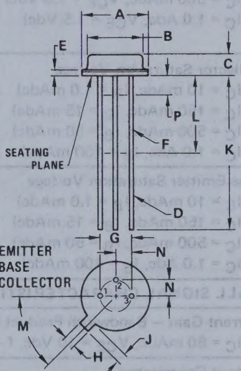
Rating	Symbol	MM3736	MM3737	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CB}	50	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	1.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.4		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Air	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	88	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}			Vdc
(I_C = 10 mAdc, I_B = 0)	MM3736		30	–	
	MM3737		50	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	MM3736		50		
	MM3737		75		
Emitter-Base Breakdown Voltage		BV_{EBO}	5.0	–	Vdc
(I_E = 10 μAdc, I_C = 0)					
Collector Cutoff Current		I_{CEV}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2.0 Vdc)	MM3736		–	0.5	
(V_{CE} = 25 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C)	MM3736		–	50	
(V_{CE} = 40 Vdc, V_{EB} = 2.0 Vdc)	MM3737		–	0.5	
(V_{CE} = 40 Vdc, V_{EB} = 2.0 Vdc, T_A = 100°C)	MM3737		–	50	
Base Cutoff Current		I_{BEV}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2.0 Vdc)	MM3736		–	0.5	
(V_{CE} = 40 Vdc, V_{EB} = 2.0 Vdc)	MM3737			0.5	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			35	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			35	–	
(I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)	MM3736		30	120	
	MM3737		20	80	
Collector Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.2	
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	0.9	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.8	
(I_C = 150 mAdc, I_B = 15 mAdc)			–	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.2	
(I_C = 1.0 Adc, I_B = 100 mAdc)			0.9	1.4	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f - 100 MHz)		f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	9.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	80	pF

SWITCHING CHARACTERISTICS

		Symbol	Min	Max	Unit
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc) I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_d	–	8.0	ns
Rise Time		t_r	–	40	ns
Turn-On Time		t_{on}		45	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_s	–	45	ns
Fall Time		t_f	–	30	ns
Turn-Off Time		t_{off}	–	65	ns
Total Control Charge (I_C = 1.0 Adc, I_B = 100 mAdc, V_{CC} = 30 Vdc)		Q_T	–	10	nC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

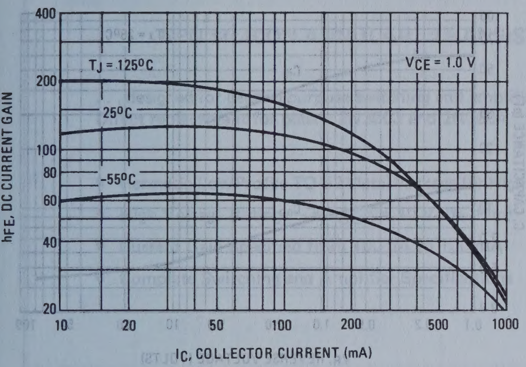


FIGURE 3 – "ON" VOLTAGES

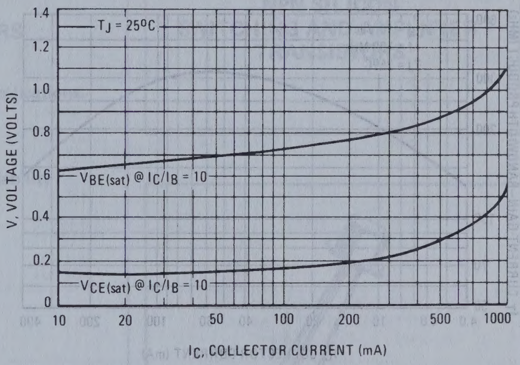


FIGURE 4 – COLLECTOR SATURATION REGION

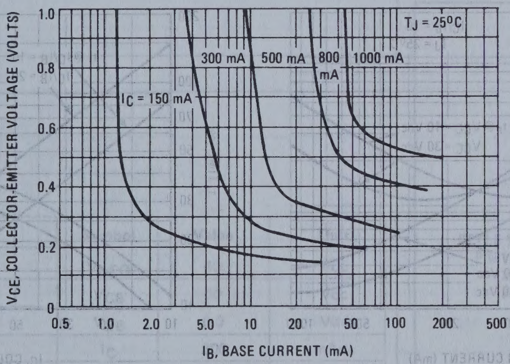


FIGURE 5 – TEMPERATURE COEFFICIENTS

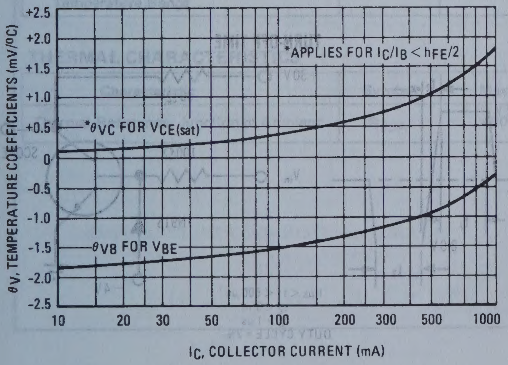
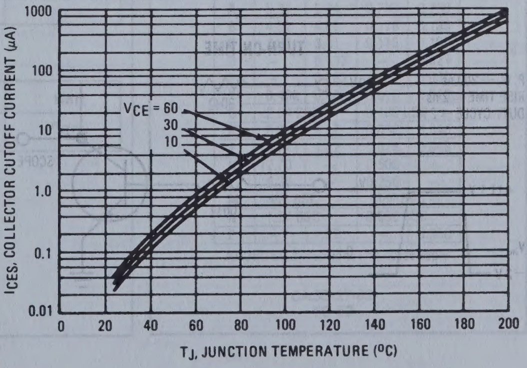


FIGURE 6 – COLLECTOR CUTOFF CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 7 – CURRENT GAIN – BANDWIDTH PRODUCT

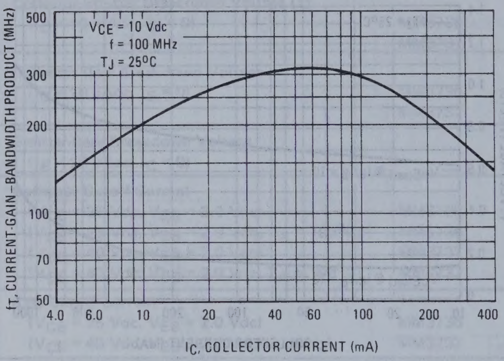


FIGURE 8 – CAPACITANCE

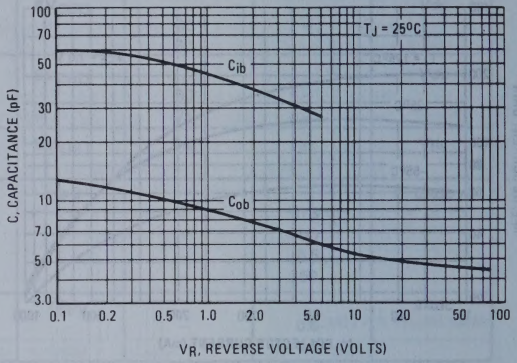


FIGURE 9 – TURN-ON TIME

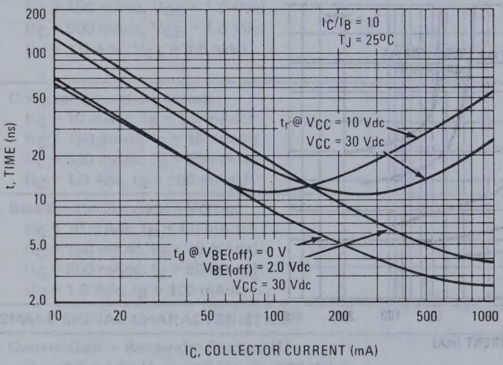


FIGURE 10 – TURN-OFF-TIME

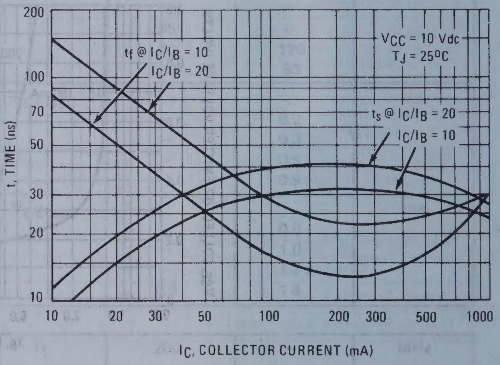
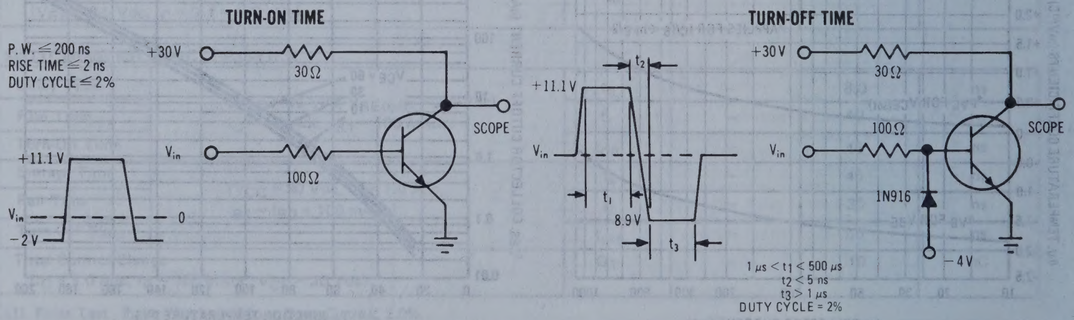


FIGURE 11 – SWITCHING TIME TEST CIRCUIT


TURN-ON TIME
P. W. ≤ 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 2%
+30 V
30 Ω
SCOPE
V_{in}
100 Ω
+11.1 V
V_{in}
0
−2 V
TURN-OFF TIME
t_2
+11.1 V
V_{in}
t_1
8.9 V
t_3
+30 V
30 Ω
100 Ω
SCOPE
V_{in}
1N916
−4 V
1 μs < t_1 < 500 μs
t_2 < 5 ns
t_3 > 1 μs
DUTY CYCLE = 2%

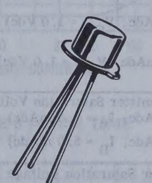
MM3903 (SILICON)
MM3904

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications. Direct replacement for plastic 2N3903 and 2N3904.

- Hermetic Low Profile TO-52 Metal Package for High Reliability
- High Voltage Ratings – BV_{CEO} = 40 Volts (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS

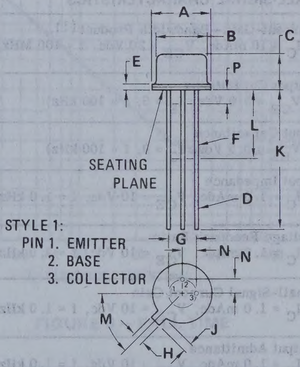


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	2.92	3.81	0.115	0.150
D	–	0.533	–	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 27-02
TO-52

MM3903, MM3904 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		-	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		-	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		-	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		-	I_{CEV}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		-	I_{BEV}	-	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904	15	h_{FE}	20 40	- -	-
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			35 70	- -	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			30 60	- -	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MM3903 MM3904			10 15	- -	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		16, 17	$V_{CE(sat)}$	- -	0.2 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		17	$V_{BE(sat)}$	0.65 -	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MM3903 MM3904	-	f_T	250 300	- -	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903 MM3904	13	h_{ie}	0.5 1.0	8.0 10	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903 MM3904	14	h_{re}	0.1×10^{-4} 0.5×10^{-4}	5×10^{-4} 8×10^{-4}	-
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903 MM3904	11	h_{fe}	50 100	200 400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		12	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	MM3903 MM3904	9, 10	NF	- -	6.0 5.0	dB
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	1, 5	t_d	-	35	ns
Rise Time		1, 5, 6	t_r	-	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MM3903 MM3904	2, 7	t_s	- -	175 200	ns
Fall Time		2, 8	t_f	-	50	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

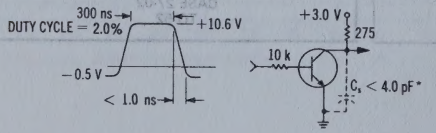
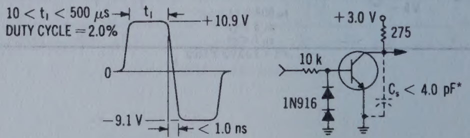


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

——— $T_J = 25^oC$ – – – – – $T_J = 125^oC$

FIGURE 3 – CAPACITANCE

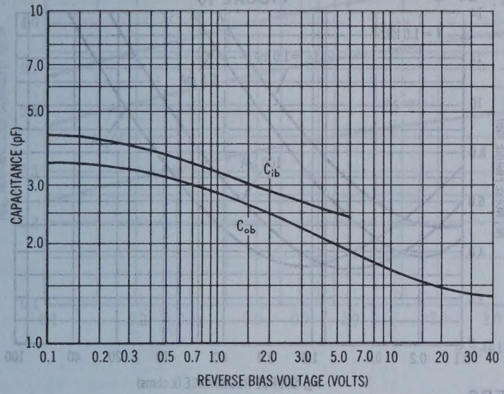


FIGURE 4 – CHARGE DATA

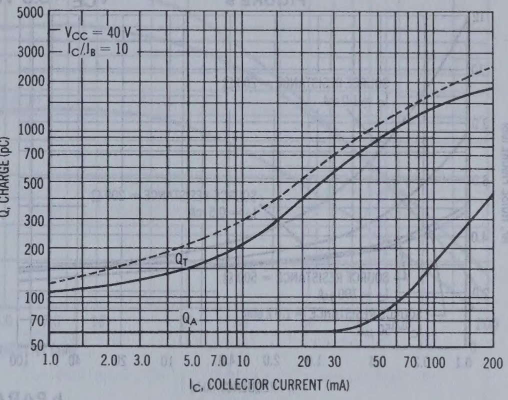


FIGURE 5 – TURN-ON TIME

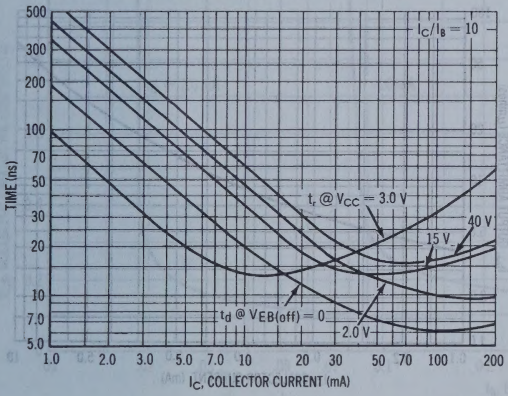


FIGURE 6 – RISE TIME

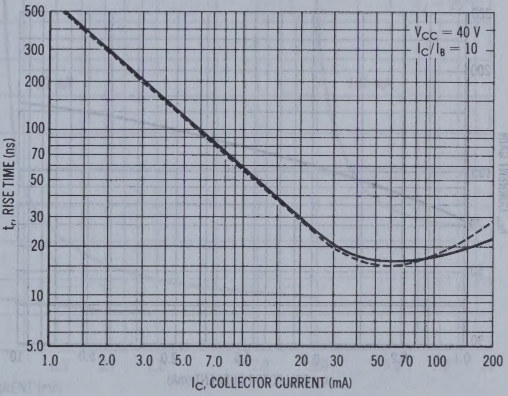


FIGURE 7 – STORAGE TIME

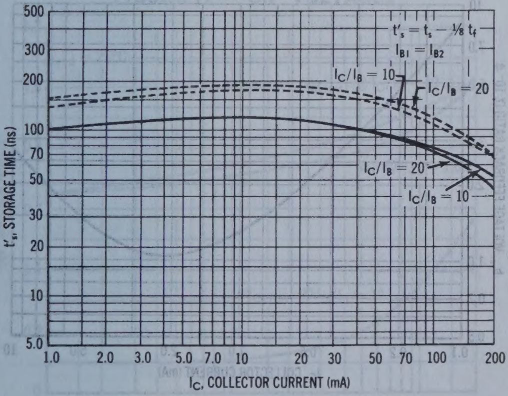
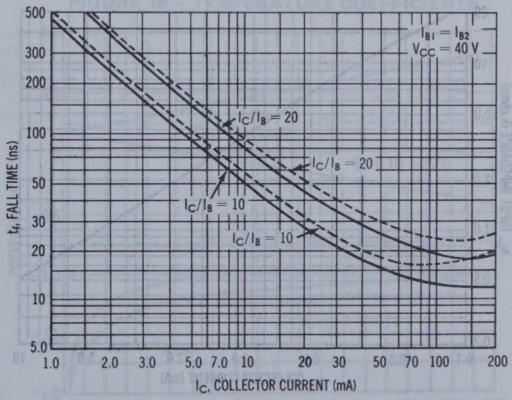


FIGURE 8 – FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 9

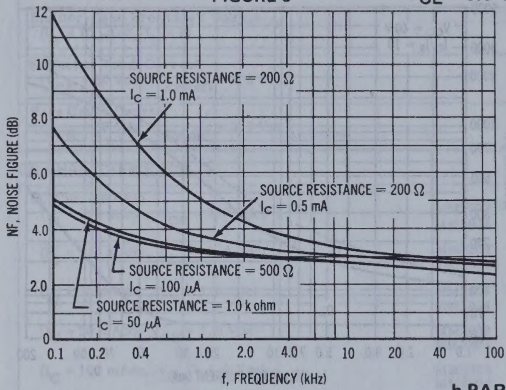
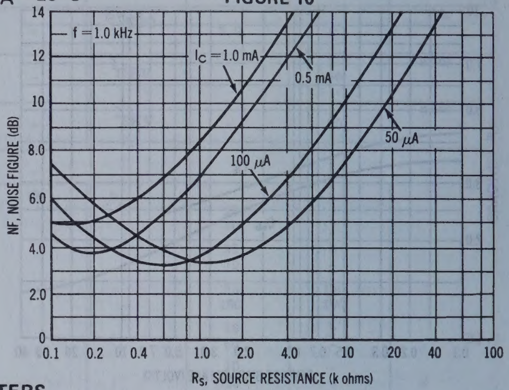


FIGURE 10



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

FIGURE 11 – CURRENT GAIN

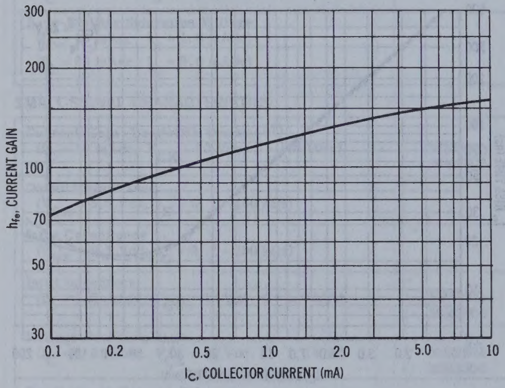


FIGURE 12 – OUTPUT ADMITTANCE

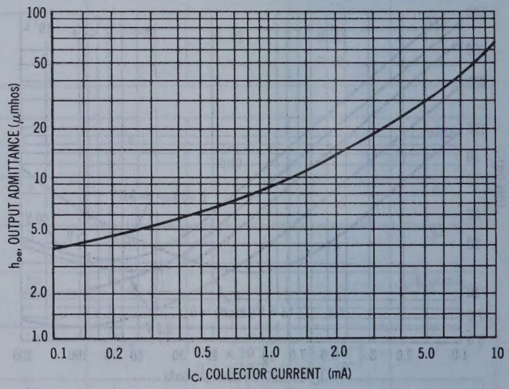


FIGURE 13 – INPUT IMPEDANCE

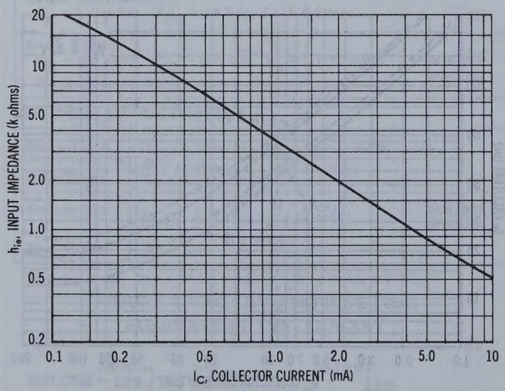
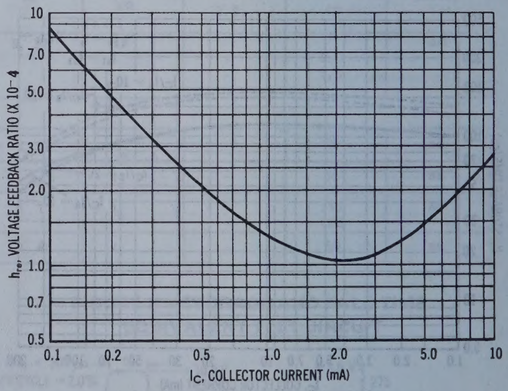


FIGURE 14 – VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 — NORMALIZED CURRENT GAIN

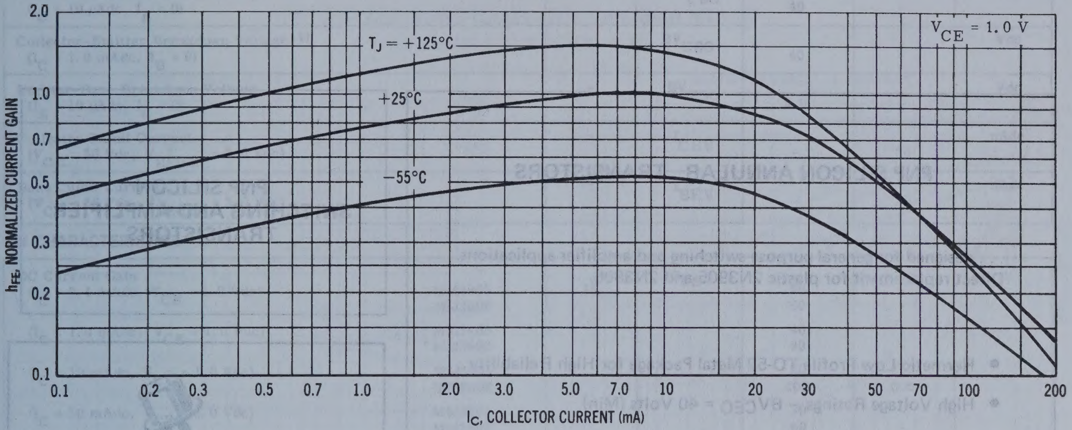


FIGURE 16 — COLLECTOR SATURATION REGION

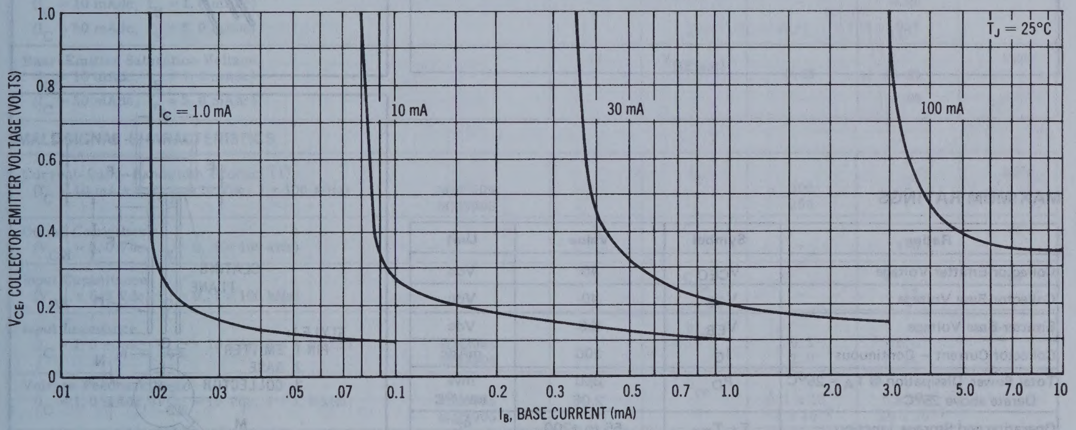


FIGURE 17 — "ON" VOLTAGES

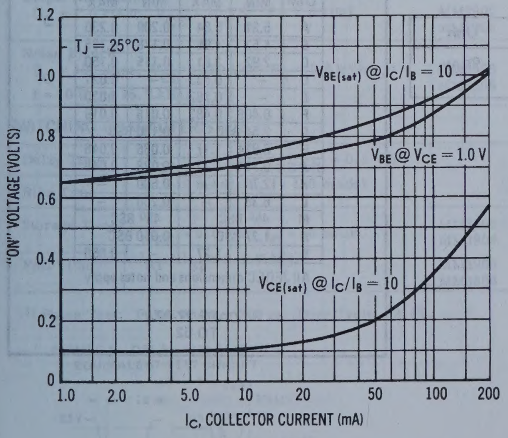
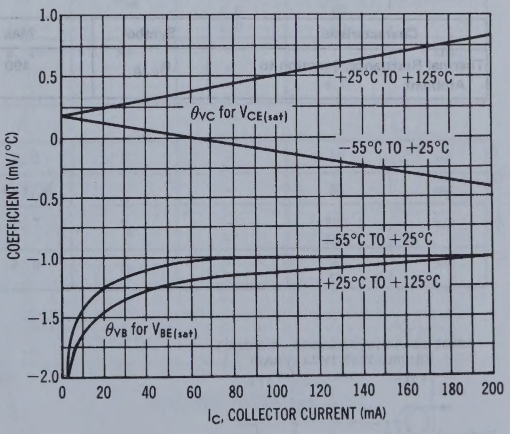


FIGURE 18 — TEMPERATURE COEFFICIENTS



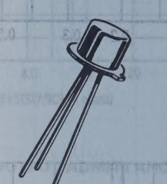
MM3905 (SILICON)
MM3906

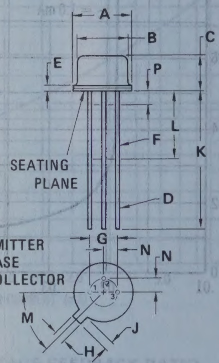
PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications. Direct replacement for plastic 2N3905 and 2N3906.

- Hermetic Low Profile TO-52 Metal Package for High Reliability
- High Voltage Ratings — BV_{CEO} = 40 Volts (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	2.92	3.81	0.115	0.150
D	–	0.533	–	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 27-02
TO-52

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

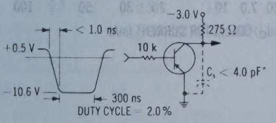
MM3905, MM3906 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	-	BV_{CBO}	40	-	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	-	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	-	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)	-	I_{CEV}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)	-	I_{BEV}	-	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) MM3905 MM3906	15	h_{FE}	30 60	- -	-
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) MM3905 MM3906			40 80	- -	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc) MM3905 MM3906			50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc) MM3905 MM3906			30 60	- -	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc) MM3905 MM3906			10 15	- -	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	16, 17	$V_{CE(sat)}$	- -	0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	17	$V_{BE(sat)}$	0.65 -	0.85 0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) MM3905 MM3906	-	f_T	200 250	- -	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	3	C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	3	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MM3905 MM3906	13	h_{ie}	0.5 2.0	8.0 12	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MM3905 MM3906	14	h_{re}	0.1×10^{-4} 1×10^{-4}	5×10^{-4} 10×10^{-4}	-
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MM3905 MM3906	11	h_{fe}	50 100	200 400	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MM3905 MM3906	12	h_{oe}	1.0 3.0	40 60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz) MM3905 MM3906	9, 10	NF	- -	5.0 4.0	dB
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	1, 5	t_d	-	35	ns
Rise Time	1, 5, 6	t_r	-	35	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, $I_{B1} = I_{B2}$ = 1.0 mAdc) MM3905 MM3906	2, 7	t_s	- -	200 225	ns
Fall Time MM3905 MM3906	2, 8	t_f	- -	60 75	ns

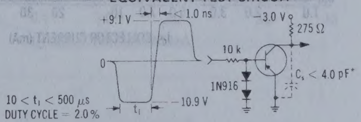
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



TRANSIENT CHARACTERISTICS

—$T_J = 25^{\circ}C$ ---$T_J = 125^{\circ}C$

FIGURE 3 – CAPACITANCE

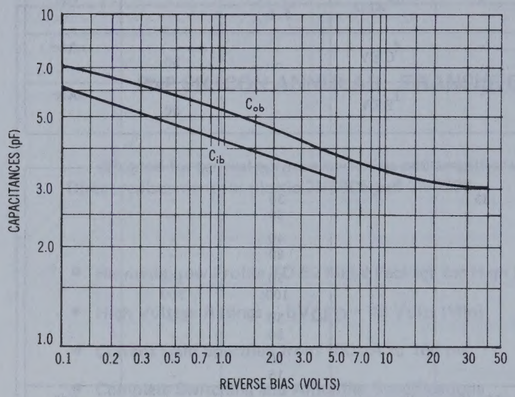


FIGURE 4 – CHARGE DATA

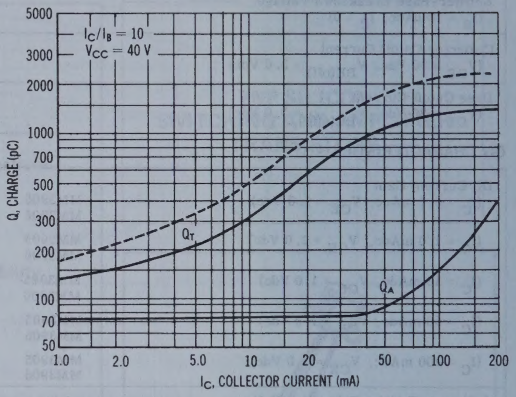


FIGURE 5 – TURN-ON TIME

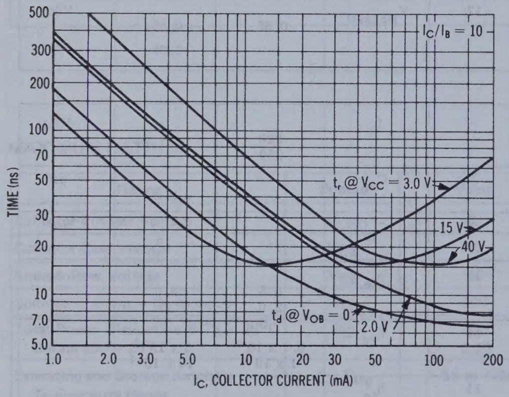


FIGURE 6 – RISE TIME

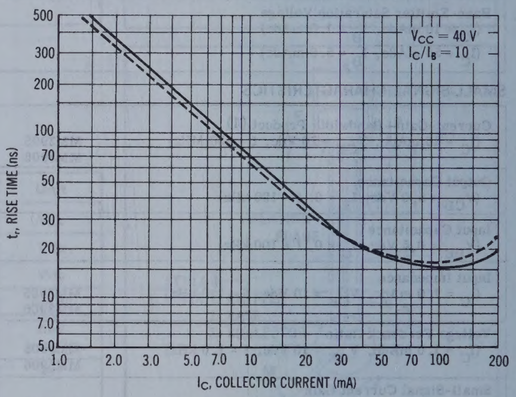


FIGURE 7 – STORAGE TIME

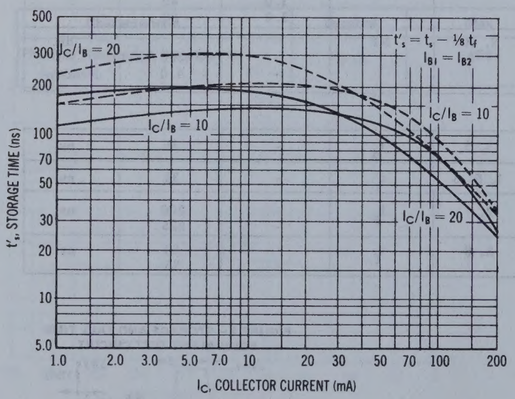
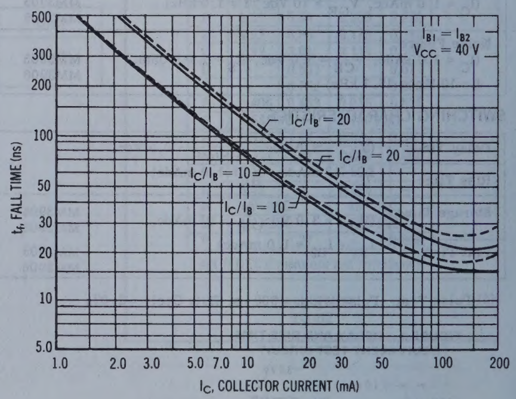


FIGURE 8 – FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 9

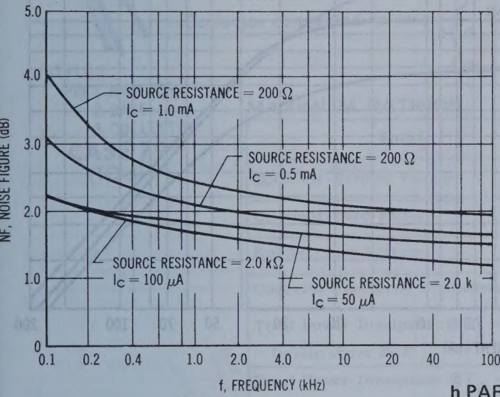
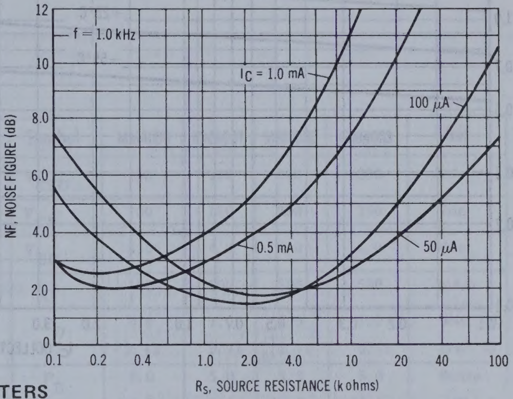


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 – CURRENT GAIN

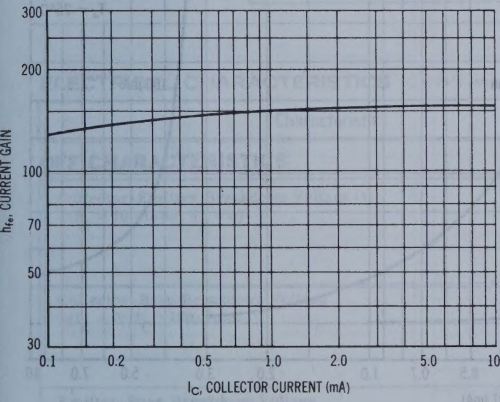


FIGURE 12 – OUTPUT ADMITTANCE

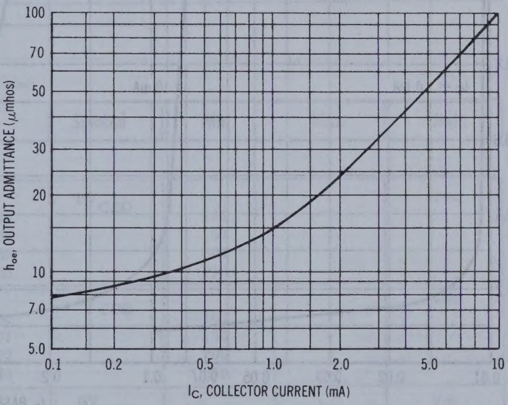


FIGURE 13 – INPUT IMPEDANCE

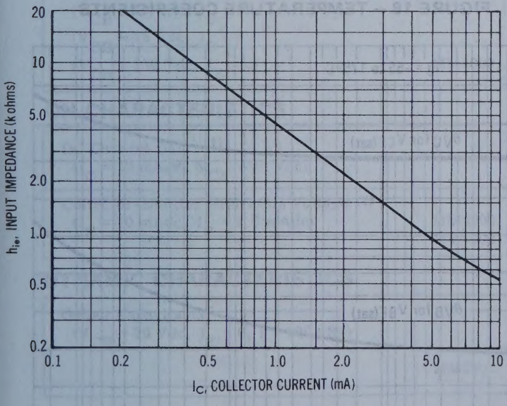
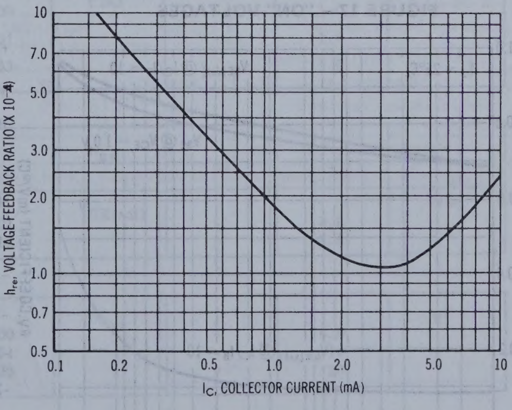


FIGURE 14 – VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 – NORMALIZED CURRENT GAIN

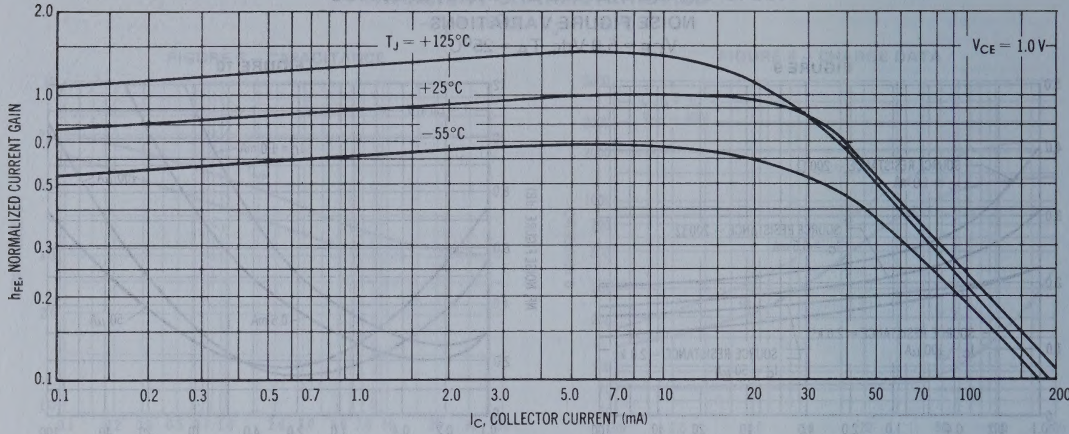


FIGURE 16 – COLLECTOR SATURATION REGION

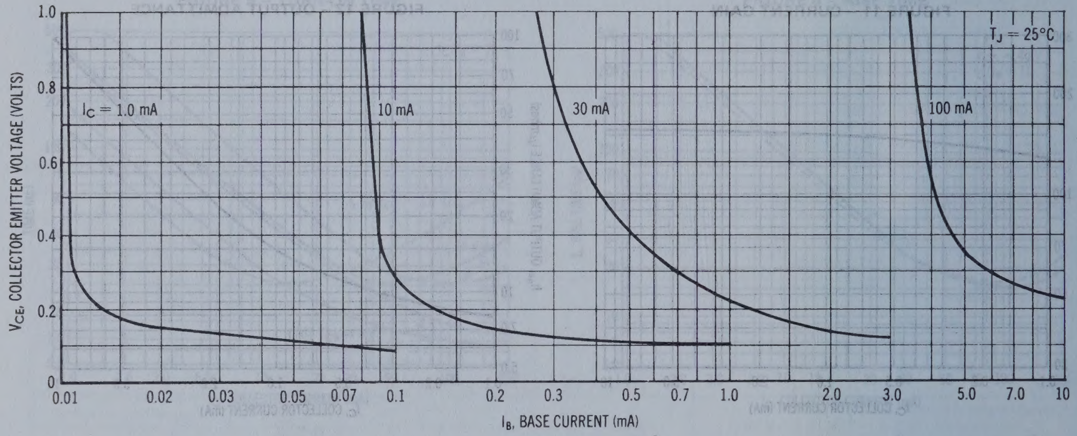


FIGURE 17 – "ON" VOLTAGES

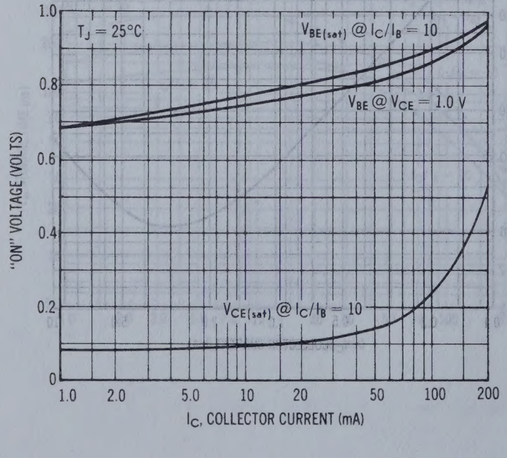
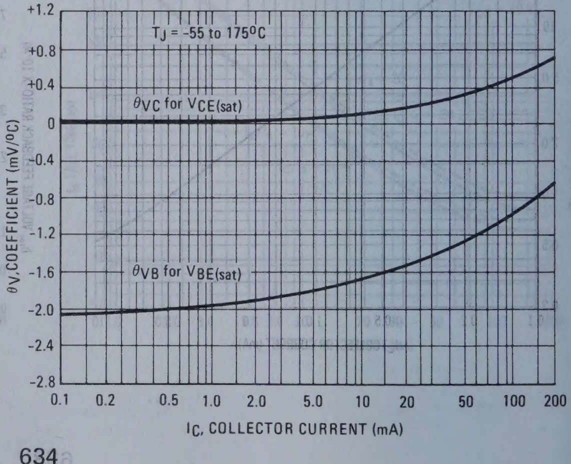
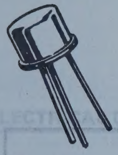


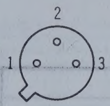
FIGURE 18 – TEMPERATURE COEFFICIENTS



MM4000 thru MM4003 (SILICON)

High-voltage PNP silicon annular transistors for use in general-purpose, high-voltage applications.





Collector connected to case

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-5)

MAXIMUM RATINGS

Rating	Symbol	MM4000	MM4001	MM4002	MM4003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CB}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.42	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MM4000 MM4001 MM4002 MM4003	BV_{CEO}	100 150 200 250	- - - -	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = 100 μAdc)	MM4000 MM4001 MM4002 MM4003	BV_{CBO}	100 150 200 250	- - - -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 150 Vdc, I_E = 0)	MM4000 MM4001 MM4002, MM4003	I_{CBO}	- - -	1.0 1.0 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	-	-
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	MM4000, MM4001 MM4002, MM4003	$V_{CE(sat)}$	- -	0.6 5.0	Vdc
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM4000 MM4001 MM4002, MM4003	C_{ob}	- - -	6.0 10 20	pF

(1) **Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%**

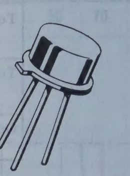
MM4005 (SILICON)
thru
MM4007

PNP SILICON ANNULAR AMPLIFIER

. . . designed for use in general-purpose amplifier applications.

- Collector-Emitter Breakdown Voltage @ I_C = 10 mAdc
  BV_{CEO} = 60 Vdc (Min) – MM4005
  = 80 Vdc (Min) – MM4006
  = 100 Vdc (Min) – MM4007
- Current-Gain–Bandwidth Product –
  f_T = 250 MHz (Typ) @ I_C = 50 mAdc

PNP SILICON AMPLIFIER TRANSISTORS



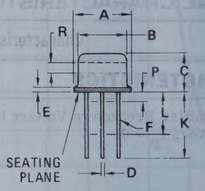
MAXIMUM RATINGS

Rating	Symbol	MM4005	MM4006	MM4007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous	I_C	1.0			Adc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.71			Watt mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	7.0 40			Watts mW/^oC
Operating & Storage Junction	T_J, T_{stg}	-65 to +200			^oC

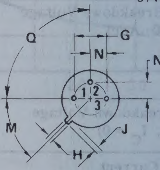
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MM4005 MM4006 MM4007	BV_{CEO}	60 80 100	– – –	– – –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM4005 MM4006 MM4007	BV_{CBO}	60 80 100	– – –	– – –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MM4005 MM4006 MM4007	I_{CBO}	 – – –	 – – –	 100 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 40 50	 90 150	 – –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.1	–	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	–	0.7	–	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	10	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	100	–	pF

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

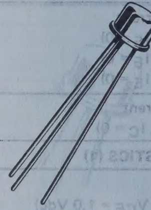
MM4008 (SILICON)
thru
MM4010

PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for use in high voltage amplifier and switching applications.

- Collector-Emitter Breakdown Voltage @ I_C = 10 mAdc
  BV_{CEO} = 60 Vdc (Min) — MM4008
  = 80 Vdc (Min) — MM4009
  = 100 Vdc (Min — MM4010
- High Current-Gain—Bandwidth Product —
  f_T = 325 MHz (Typ) @ I_C = 20 mAdc

PNP SILICON TRANSISTORS



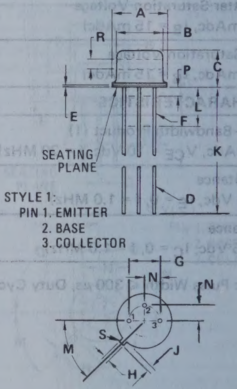
MAXIMUM RATINGS

Rating	Symbol	MM4008	MM4009	MM4010	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	← 500 →			mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	← 600 → ← 3.43 →			mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	← 2.0 → ← 1.4 →			Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	330	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	11.5	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45^0 BSC		45^0 BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MM4008 MM4009 MM4010	BV_{CEO}	60 80 100	– – –	– – –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM4008 MM4009 MM4010	BV_{CBO}	60 80 100	– – –	– – –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MM4008 MM4009 MM4010	I_{CBO}	 – – –	 – – –	 100 100 100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	75	125	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.2	–	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	–	0.7	–	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MM4008 MM4009/10	f_T	–	325 150	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	MM4008 MM4009/10	C_{ob}	–	6.0 10	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	MM4008 MM4009/10	C_{ib}	–	20 125	–	pF

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

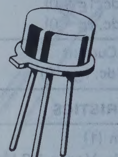
MM4018 (SILICON)

PNP SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier or oscillator applications in military and industrial equipment. Suitable for use as Class A, B, or C driver, or pre-driver stages in VHF applications.

- Power Output — P_{out} = 0.5 W (Min) @ f = 175 MHz
- High Current-Gain — Bandwidth Product — f_T = 900 MHz (Typ) @ I_C = 50 mAdc

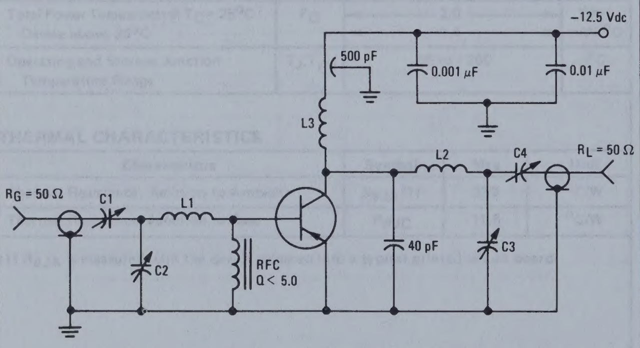
PNP SILICON
RF POWER
TRANSISTOR



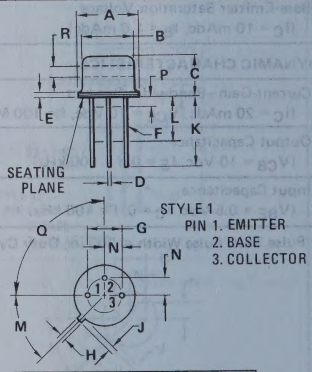
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

FIGURE 1 — 175 MHz OUTPUT POWER TEST CIRCUIT



C1, C2 3.0 – 30 pF, ARCO 461 OR EQUIVALENT
C3, C4 8.0 – 80 pF, ARCO 462 OR EQUIVALENT
L1 100 nH, 4 TURNS NO. 18 AWG, 1/4″ I.D., 5/8″ LENGTH
L2 40 nH, 2 TURNS NO. 18 AWG, 1/4″ I.D., 1/2″ LENGTH
L3 200 nH, 8 TURNS NO. 18 AWG, 1/4″ I.D., 7/8″ LENGTH



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 5.0$ mAdc, $I_E = 0$)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $I_B = 0$)	I_{CEO}	–	–	20	µAdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $V_{BE} = 0$)	I_{CES}	–	–	0.1	mAdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	–	–	10	µAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	10	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, f = 100 MHz)	f_T	–	900	–	MHz
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	3.5	–	pF
FUNCTIONAL TEST					
Power Output (Figure 1) ($P_{in} = 50$ mW, $V_{CC} = 12.5$ Vdc, f = 175 MHz)	P_{out}	0.5	–	–	Watt
Collector Efficiency (Figure 1) ($P_{in} = 50$ mW, $V_{CC} = 12.5$ Vdc, f = 175 MHz)	η	45	55	–	%

FIGURE 2 – POWER OUTPUT versus POWER INPUT

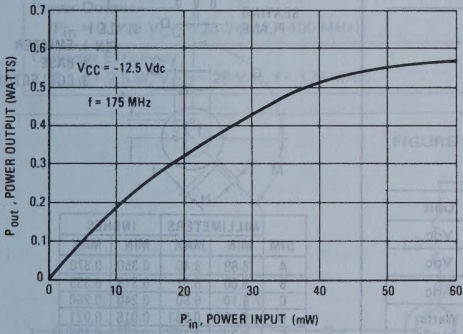


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

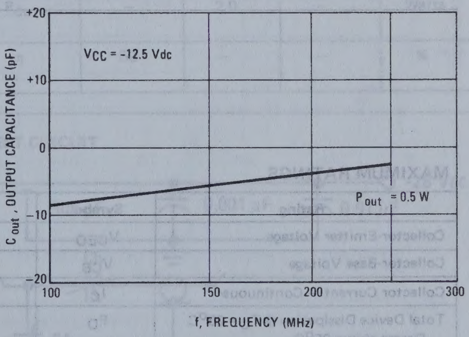


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

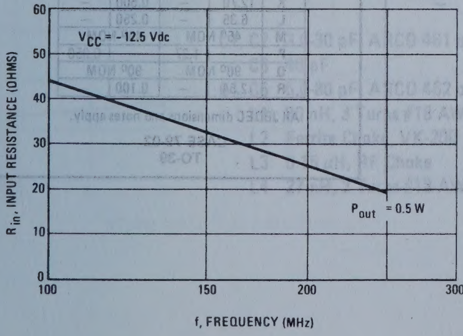
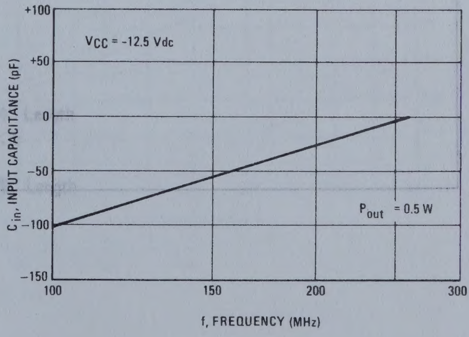


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



MM4019 (SILICON)

PNP SILICON RF POWER TRANSISTOR

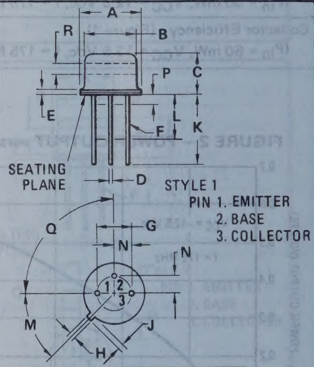
. . . designed for use as complement to NPN 2N3553 in VHF and UHF amplifier applications for military and industrial equipment.

- Power Output – P_{out} = 2.0 W (Typ) @ P_{in} = 0.5 W, f = 400 MHz
- Power Input – P_{in} = 0.25 W (Max) @ P_{out} = 2.5 W, f = 175 MHz

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

PNP SILICON RF POWER TRANSISTOR



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

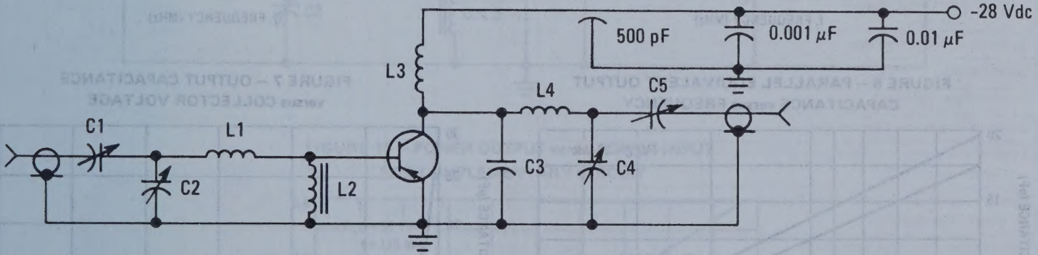
All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25° unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 mAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 Adc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	–	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	–	750	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	7.5	–	pF
FUNCTIONAL TEST					
Power Input (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	P_{in}	–	–	0.25	Watt
Power Output (P_{in} = 0.5 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{out}	–	2.0	–	Watts
Collector Efficiency (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	η	50	–	–	%

FIGURE 1 — 175 MHz TEST CIRCUIT



C1, C2 3.0-30 pF, ARCO 461 or equivalent.
C3 40 pF
C4, C5 5.0-80 pF, ARCO 462 or equivalent.
L1 80 nH, 3 Turns #18 AWG, 1/4" I.D., 1/4" Length
L2 Ferrite Choke, VK-200 Ferroxcube, Q < 5
L3 0.15 µH, RF Choke
L4 27 nH, 2 Turns #18 AWG, 1/4" I.D., 3/8" Length

FIGURE 2 – POWER OUTPUT versus FREQUENCY

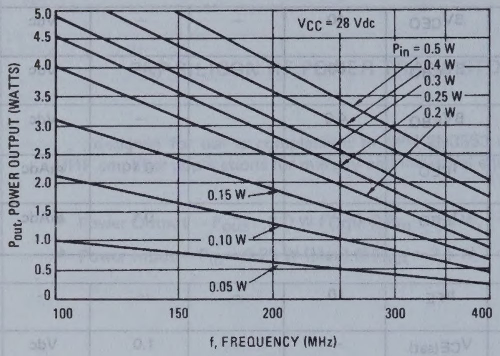


FIGURE 3 – POWER OUTPUT versus POWER INPUT

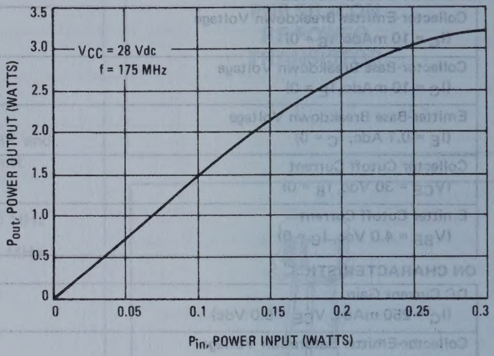


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

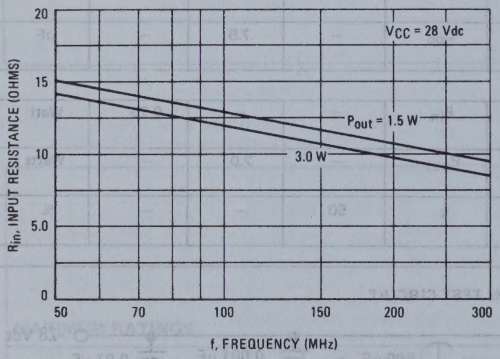


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

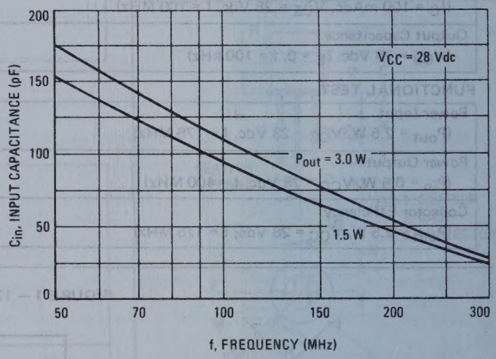


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

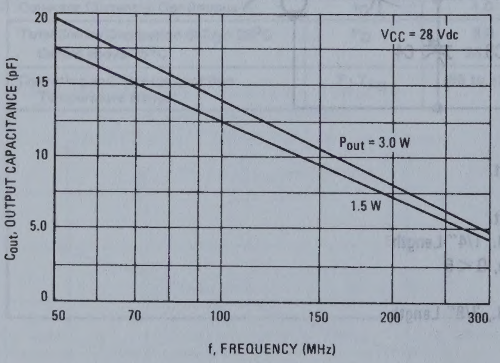


FIGURE 7 – OUTPUT CAPACITANCE versus COLLECTOR VOLTAGE

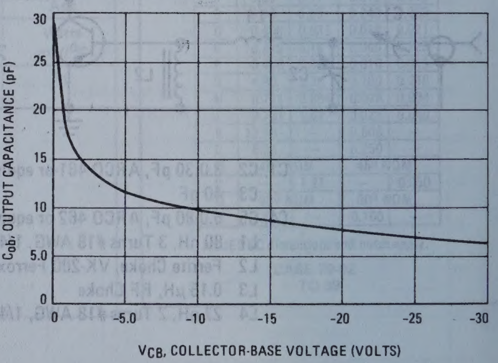


FIGURE 8 – CURRENT-GAIN–BANDWIDTH PRODUCT

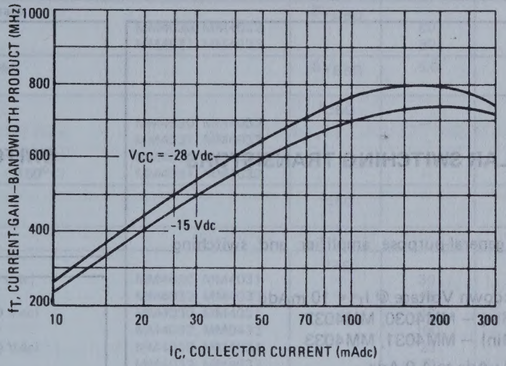
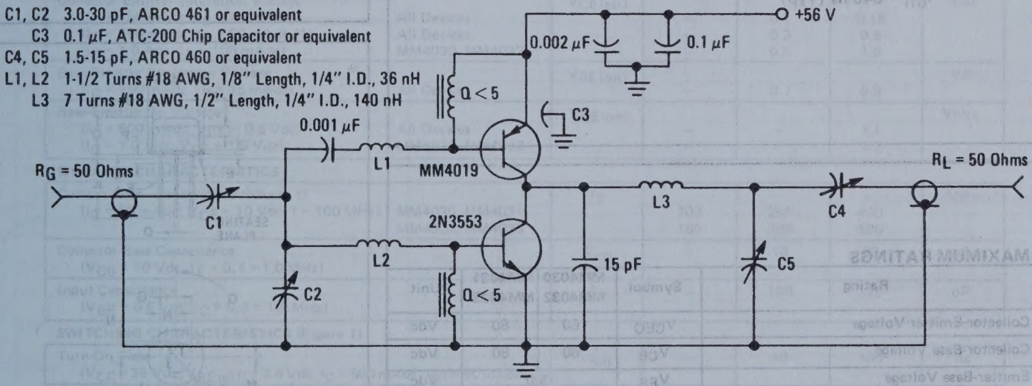
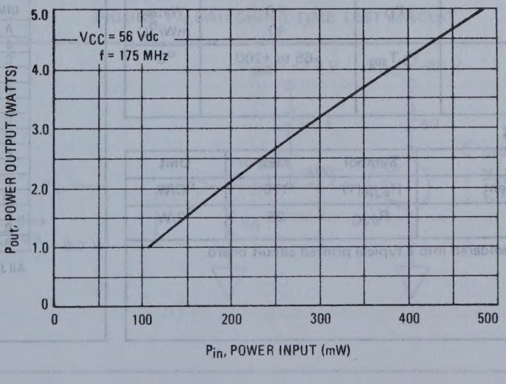


FIGURE 9 – MM4019/2N3553 COMPLEMENTARY 175 MHz AMPLIFIER CIRCUIT


C1, C2 3.0-30 pF, ARCO 461 or equivalent
C3 0.1 µF, ATC-200 Chip Capacitor or equivalent
C4, C5 1.5-15 pF, ARCO 460 or equivalent
L1, L2 1-1/2 Turns #18 AWG, 1/8" Length, 1/4" I.D., 36 nH
L3 7 Turns #18 AWG, 1/2" Length, 1/4" I.D., 140 nH

+56 V
0.002 µF
0.1 µF
Q < 5
C3
0.001 µF
L1
MM4019
R_G = 50 Ohms
C1
2N3553
L2
C2
Q < 5
L3
15 pF
C5
C4
R_L = 50 Ohms

FIGURE 10 – POWER OUTPUT versus POWER INPUT FOR COMPLEMENTARY CIRCUIT



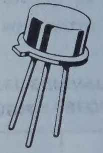
MM4030 (SILICON)
thru
MM4033

PNP SILICON ANNULAR SWITCHING TRANSISTORS

. . . designed for use in general-purpose amplifier and switching applications.

- Collector Emitter Breakdown Voltage @ I_C = 10 mAdc
  BV_{CEO} = 60 Vdc (Min) – MM4030, MM4032
  = 80 Vdc (Min) – MM4031, MM4033
- DC Current Gain – 100 μAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.5 Vdc (Typ) @ I_C = 1.0 Adc
- Fast Switching Time @ I_C = 500 mAdc
  t_{on} = 55 ns (Typ)
  t_{off} = 340 ns (Typ)

PNP SILICON SWITCHING TRANSISTORS



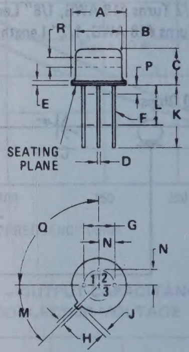
MAXIMUM RATINGS

Rating	Symbol	MM4030 MM4032	MM4031 MM4033	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

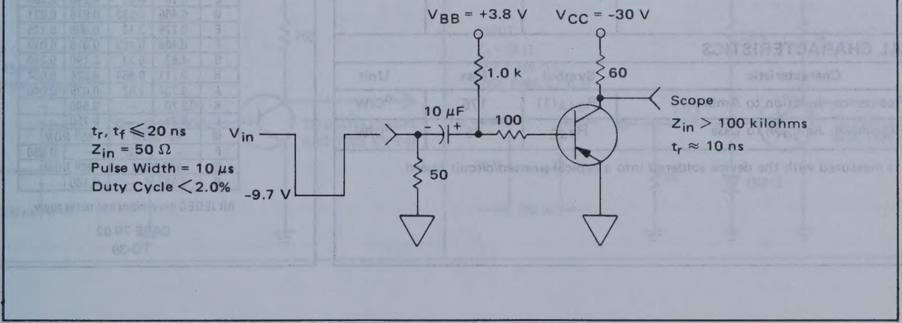
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	MM4030, MM4032		60	–	–	
	MM4031, MM4033		80	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 10 μAdc, I_E = 0)	MM4030, MM4032		60	–	–	
	MM4031, MM4033		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 50 Vdc, I_E = 0)	MM4030, MM4032		–	–	50	nAdc
(V_{CB} = 60 Vdc, I_E = 0)	MM4031, MM4033		–	–	50	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	MM4030, MM4032		–	–	50	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	MM4031, MM4033		–	–	50	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	–	10	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MM4030, MM4031		30	50	–	
	MM4032, MM4033		75	110	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MM4030, MM4031		40	80	120	
	MM4032, MM0433		100	150	300	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	MM4030, MM4031		25	40	–	
	MM4032, MM4033		70	100	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	MM4030		15	35	–	
	MM4031		10	30	–	
	MM4032		40	60	–	
	MM4033		25	50	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	MM4030, MM4031		15	–	–	
	MM4032, MM4033		40	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	All Devices		–	0.1	0.15	
(I_C = 500 mAdc, I_B = 50 mAdc (1)	All Devices		–	0.3	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)	MM4030, MM4032		–	0.5	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	All Devices		–	0.7	0.9	
Base-Emitter On Voltage		$V_{BE(on)}$				Volts
(I_C = 500 mAdc, V_{CE} = 0.5 Vdc)	All Devices		–	–	1.1	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MM4030, MM4032		–	–	1.2	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (1)		f_T				MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MM4030, MM4031		100	250	400	
	MM4032, MM4033		150	300	500	
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	–	10	20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	100	125	pF
SWITCHING CHARACTERISTICS (Figure 1)						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)		t_{on}	–	40	100	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	–	240	–	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)		t_s	–	200	350	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



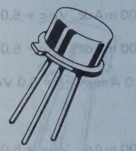
MM4036 (SILICON)

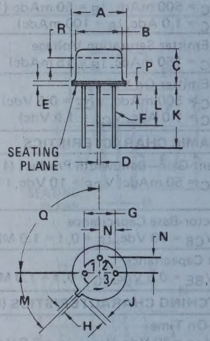
PNP SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in general purpose amplifier and switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 65 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain — 100 μAdc to 500 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Typ) @ I_C = 150 mAdc
- Fast Switching Times @ I_C = 150 mAdc
  - t_{on} = 90 ns (Typ)
  - t_{off} = 450 ns (Typ)

PNP SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Base Current — Continuous	I_B	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	65	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	BV_{CBO}	90	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 µAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	–	–	250	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	250	nAdc
Collector Cutoff Current (2) (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEV}	 – –	 – –	 250 100	 nAdc µAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 100 µAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 2.0 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 20 20 40 20	 50 60 90 40	 – 200 140 –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.3	0.65	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	1.0	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	100	–	MHz
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1a)	t_{on}	–	40	75	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 1b)	t_{off}	–	110	175	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

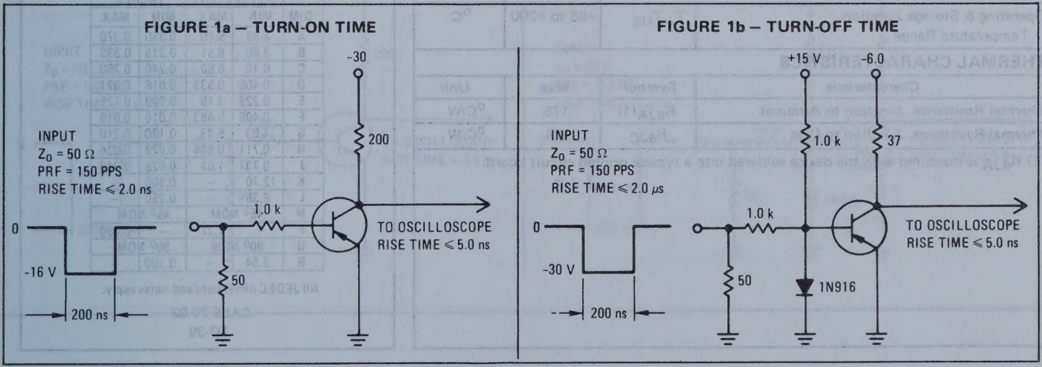


FIGURE 1a – TURN-ON TIME

FIGURE 1b – TURN-OFF TIME
-30
200
INPUT
Z0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 ns
1.0 k
0
-16 V
50
200 ns
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns
+15 V
-6.0
INPUT
Z0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 µs
1.0 k
37
1.0 k
0
-30 V
50
1N916
200 ns
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns

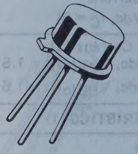
MM4037 (SILICON)

PNP SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use in general-purpose amplifier and switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Typ) @ I_C = 150 mAdc

PNP SILICON TRANSISTOR



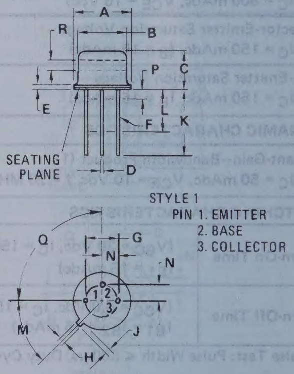
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Base Current	I_B	500	mAdc
Total Power Dissipation $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	1.0 5.71	Watt mW/°C
Total Power Dissipation $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	7.0 40	Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted).

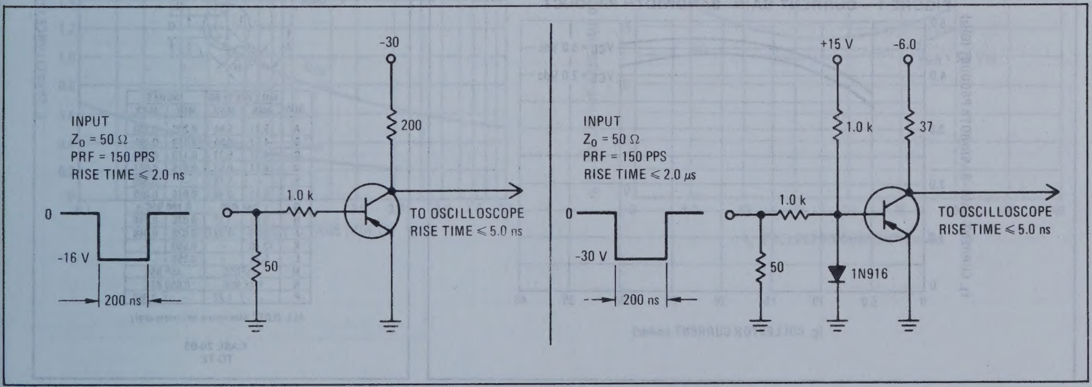
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	–	–	250	Adc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	1.0	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 15 50	 50 75	 – 250	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.3	1.4	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, I_B = 10 mVdc)	$V_{BE(on)}$	–	0.8	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	100	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	20	30	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	60	–	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (I_C = 150 mAdc, I_B = 15 mAdc) (Figure 1a)	t_{on}	–	40	75	ns
Turn-Off Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, I_{B2} = 15 mAdc) (Figure 1b)	t_{off}	–	110	175	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

1a – TURN-ON TIME

1b – TURN-OFF TIME


-30
200
INPUT
Z_0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 ns
1.0 k
0
-16 V
50
200 ns
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns
+15 V
-6.0
1.0 k
37
INPUT
Z_0 = 50 Ω
PRF = 150 PPS
RISE TIME ≤ 2.0 μs
1.0 k
0
-30 V
50
1N916
200 ns
TO OSCILLOSCOPE
RISE TIME ≤ 5.0 ns

MM4049 (SILICON)

The RF Line

PNP SILICON HIGH-FREQUENCY TRANSISTOR

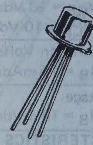
. . . designed for use as a high-frequency current mode switch. Because of the extremely high Current-Gain–Bandwidth this transistor also makes an excellent RF amplifier and oscillator.

- High Current-Gain–Bandwidth Product – f_T = 4.0 GHz (Min) @ I_C = 20 mAdc
- Low Collector-Base Capacitance – C_{cb} = 1.25 pF (Max) @ V_{CB} = 5.0 Vdc

4.0 GHz @ 20 mAdc

HIGH FREQUENCY TRANSISTOR

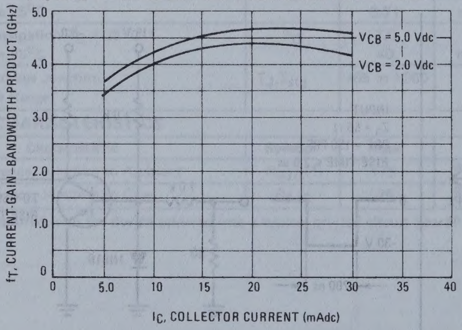
PNP SILICON

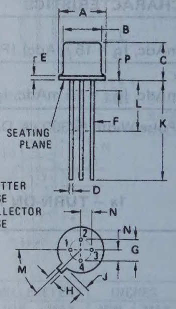


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current – Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 – CURRENT-GAIN–BANDWIDTH PRODUCT





STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	BV_{CEO}	10	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.5	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	20	200	–
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (Figure 1) (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz)	f_T	4.0	–	GHz
Collector-Base Capacitance (Figure 2) (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	1.25	pF
Emitter-Base Capacitance (Figure 2) (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	–	1.25	pF
Collector-Base Time Constant (Figure 3) (I_E = 15 mAdc, V_{CB} = 5.0 Vdc, f = 63.6 MHz)	$r_b'C_c$	–	15	ps

FIGURE 2 – CAPACITANCES

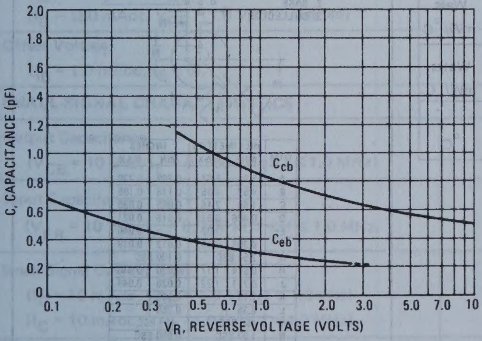
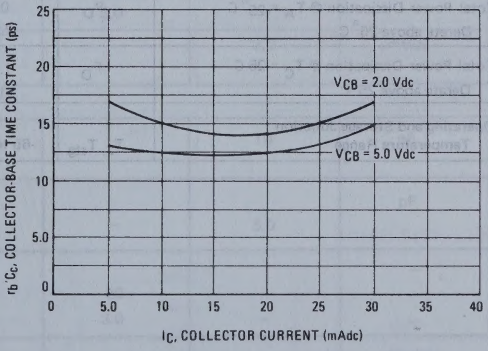


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT



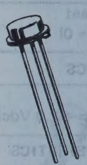
MM4052 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for bilateral switching and high-level chopper applications such as servo-loop circuitry and control amplifiers for motor drive systems. These transistors can also be used as replacement devices for alloy-type transistors where high BV_{EBO} is required.

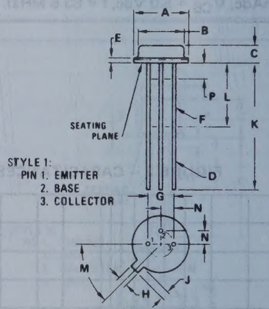
- High Emitter–Base Breakdown Voltage –
  BV_{EBO} = 30 Vdc (Min) @ I_E = 100 μAdc
- Inverted DC Current Gain – 3.0 (Min) @ I_C = 150 mAdc
- Low Emitter-Collector Offset Voltage –
  $V_{EC(ofs)}$ = 2.0 mVdc (Max) @ I_B = 1.0 mAdc
- Low "ON" Series Resistance –
  $r_{ec(ON)}$ = 2.0 Ohms (Max) @ I_B = 10 mAdc

PNP SILICON CHOPPER AND SWITCHING TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Collector Voltage	V_{EC}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25° C Derate above 25° C	P_D	0.5 2.86	Watt mW/°C
Total Power Dissipation @ T_C = 25 C Derate above 25 C	P_D	1.75 10	Watts mW/ C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS (T_A = 25° C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	Vdc
Emitter-Collector Breakdown Voltage [1] (I_E = 10 mAdc, I_B = 0)	BV_{ECO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	30	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	nAdc
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	I_{EBO}	–	0.5	nAdc
ON CHARACTERISTICS				
DC Current Gain [1]	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		20	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		15	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (Inverted)		3.0	–	
Offset Voltage (I_B = 1.0 mAdc, I_E = 0)	$V_{EC(ofs)}$	–	2.0	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{EB} = 10 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ib}	–	5.0	pF
Small-Signal Current Gain	h_{fe}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 kHz)		20	–	–
(I_C = 10 mAdc, V_{CE} - 1.0 Vdc, f = 4.0 MHz)		3.0	–	–
"ON" Series Resistance (I_B = 10 mAdc, f = 1.0 kHz)	$r_{ec(ON)}$	–	2.0	Ohms

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 20%

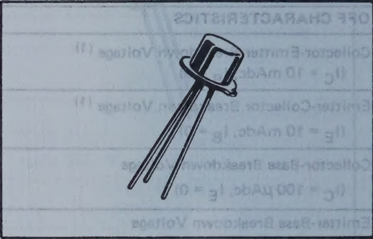
MM4208, MM4208A (SILICON)
MM4209, MM4209A

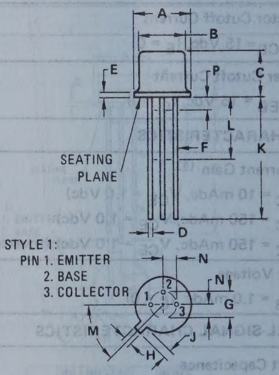
PNP SILICON ANNULAR TRANSISTORS

. . . designed for applications requiring very high-speed switching at low voltage for computer logic circuits.

- Fast Switching Times — @ I_C = 50 mAdc
  t_{on} = 15 ns (Max)
  t_{off} = 20 ns (Max)
- High Current-Gain—Bandwidth Product —
  f_T = 1300 MHz (Typ) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.18 Vdc (Max) @ I_C = 10 mAdc

PNP SILICON SWITCHING TRANSISTORS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	MM4208 MM4209	MM4208A MM4209A	Unit
Collector-Emitter Voltage	V_{CEO}	12	15	Vdc
Collector-Base Voltage	V_{CB}	12	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

SELECTOR GUIDE

Type	BV_{CEO} Volts Min	h_{FE} @ I_C = 10 mA, V_{CE} = 0.3 V Min/Max
MM4208 MM4208A	12 15	30/120 30/120
MM4209 MM4209A	12 15	50/120 50/120

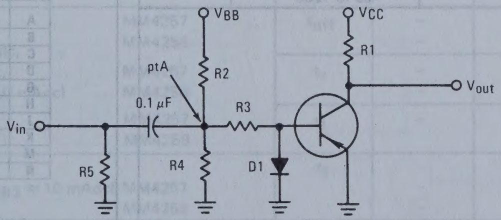
MM4208, MM4028A, MM4209, MM4209A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1)		BV_{CEO}				Vdc
(I_C = 3.0 mAdc, I_B = 0	MM4208,MM4209		12	–	–	
	MM4208A,MM4209A		15	–	–	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 100 μAdc, V_{BE} = 0)	MM4208,MM4209		12	–	–	
	MM4208A,MM4209A		15	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 100 μAdc, I_E = 0)	MM4208,MM4209		12	–	–	
	MM4208A,MM4209A		15	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.5	–	–	Vdc
Collector Cutoff Current		I_{CES}				
(V_{CE} = 6.0 Vdc, V_{BE} = 0)	MM4208,MM4209		–	–	10	nAdc
(V_{CE} = 8.0 Vdc, V_{BE} = 0)	MM4208A,MM4209A		–	–	10	
(V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 125°C)	MM4208,MM4209		–	–	5.0	μAdc
(V_{CE} = 8.0 Vdc, V_{BE} = 0, T_A = 125°C)	MM4208A,MM4209A		–	–	5.0	
Base Current		I_B				nAdc
(V_{CE} = 6.0 Vdc, V_{BE} = 0)	MM4208,MM4209		–	–	1.0	
(V_{CE} = 8.0 Vdc, V_{BE} = 0)	MM4208A,MM4209A		–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	MM4208,MM4208A		15	–	–	
	MM4209,MM4209A		35	–	–	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	MM4208,MM4208A		30	–	120	
	MM4209,MM4209A		50	–	120	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_A = -55°C)	MM4208,MM4208A		12	–	–	
	MM4209,MM4209A		20	–	–	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)(1)	MM4208,MM4208A		30	–	–	
	MM4209,MM4209A		40	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			–	–	0.15	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	–	0.18	
(I_C = 50 mAdc, I_B = 5.0 mAdc)(1)			–	–	0.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			–	–	0.8	
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.7	–	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)(1)			–	–	1.5	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	850	1300	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	–	–	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	–	–	3.5	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc)		t_{on}	–	–	15	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)		t_{off}	–	–	20	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C ≈ 10 mAdc, I_{B1} = I_{B2} ≈ 10 mAdc)		t_s	–	17	20	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



	Vin Volts	VBB Volts	VCC Volts	R1 Ohms	R2 Ohms	R3 Ohms	R4 Ohms	R5 Ohms	D1
t_{on}	-12.8	+4.0	-3.0	55	100	2.0 k	100	inf.	no
t_{off}	+20	-11.3*	-3.0	55	100	2.0 k	100	inf.	yes
t_s	+9.0	-10	-3.0	270	510	390	inf.	51	no

*At Point A (ptA) D1 must be fast recovery type, e.g., MSD6100

MM4257 (SILICON)
MM4258

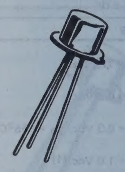
PNP SILICON ANNULAR TRANSISTORS

. . . designed for applications requiring high speed switching at low voltages.

- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.15 Vdc (Max) @ I_C = 10 mAdc
- Switching Times @ I_C = 10 mAdc —
  t_{on} = 10 ns (Typ)
  t_{off} = 10 ns (Typ)
- Hermetic Constructed Version of 2N4257 and 2N4258
- Complement to 2N2369

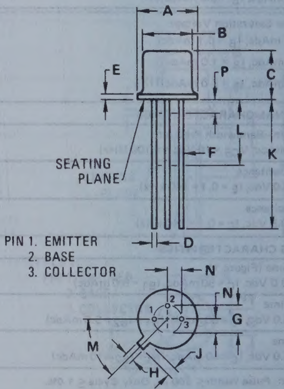
SWITCHING TRANSISTORS

PNP SILICON



MAXIMUM RATINGS

Rating	Symbol	MM4257	MM4258	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	12	Vdc
Collector-Base Voltage	V_{CB}	6.0	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current — Continuous	I_C	80		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	360 2.06		mW mW/°C
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.2 6.86		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	

Collector Connected to Case

CASE 22
TO-18

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 3.0 mAdc, I_B = 0)	MM4257	$V_{CEO(sus)}$	6.0	–	–	Vdc
	MM4258		12	–	–	
Collector-Emitter Breakdown Voltage (1) (I_C = 100 μAdc, V_{BE} = 0)	MM4257	BV_{CES}	6.0	–	–	Vdc
	MM4258		12	–	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM4257	BV_{CBO}	6.0	–	–	Vdc
	MM4258		12	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)		I_{CES}	–	–	0.01	μAdc
(V_{CE} = 3.0 Vdc, V_{BE} = 0, T_A = +65°C)			–	–	5.0	
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)		h_{FE}	15	–	–	–
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)			30	–	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			30	–	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	–	0.15	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	–	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.75	–	0.95	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	–	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	MM4257	f_T	500	–	–	MHz
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MM4258		700	–	–	
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	–	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	–	3.5	pF
SWITCHING CHARACTERISTICS (Figure 5)						
Turn-On Time (V_{CC} = 1.5 Vdc, $V_{BE(off)}$ = 0, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		t_{on}	–	10	15	ns
Delay Time		t_d	–	5.0	10	ns
Rise Time		t_r	–	5.0	15	ns
Turn-Off Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	MM4257	t_{off}	–	12	15	ns
	MM4258		–	16	20	
Storage Time	MM4257	t_s	–	6.0	15	ns
	MM4258		–	8.0	20	
Fall Time	MM4257	t_f	–	6.0	10	ns
	MM4258			8.0	10	
Storage Time (I_C ≈ 10 mAdc, I_{B1} ≈ 10 mAdc, I_{B2} ≈ 10 mAdc)	MM4257	t_s	–	–	15	ns
	MM4258		–	–	20	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

TYPICAL TRANSIENT CHARACTERISTICS

FIGURE 1 – CURRENT-GAIN – BANDWIDTH PRODUCT

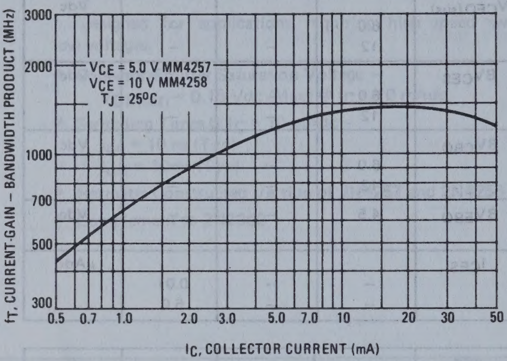


FIGURE 2 – CAPACITANCE

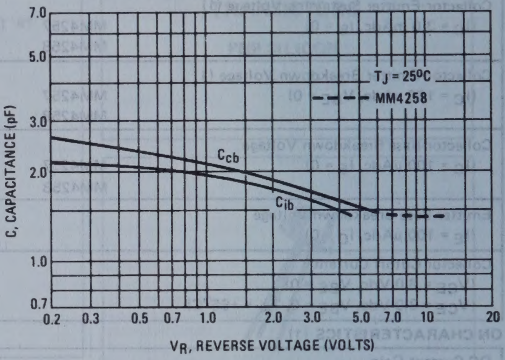


FIGURE 3 – TURN-ON TIME

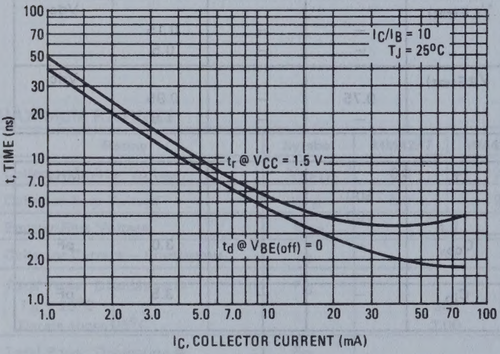


FIGURE 4 – TURN-OFF TIME

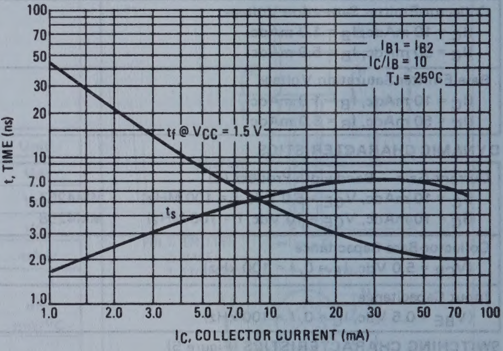
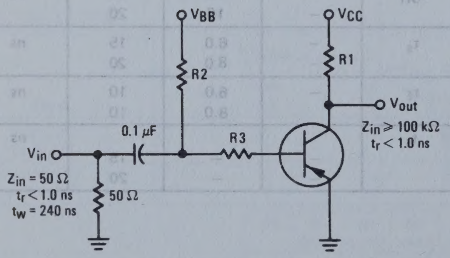


FIGURE 5 – SWITCHING TIME TEST CIRCUIT


V_{BB}
V_{CC}
R2
R1
V_{out}
Z_{in} ≥ 100 kΩ
t_r < 1.0 ns
0.1 µF
R3
V_{in}
Z_{in} = 50 Ω
t_r < 1.0 ns
t_w = 240 ns
50 Ω

	V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R1 Ohms	R2 Ohms	R3 Ohms	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	GND	-1.5	130	2.2 k	5 k	10	1.0	–
t_{off}	+9.8	-8.0	-1.5	130	2.2 k	5 k	10	1.0	1.0
t_s	+9.0	-10	-3.0	270	510	390	10	10	10

DC CURRENT GAIN

FIGURE 6 – MM4257

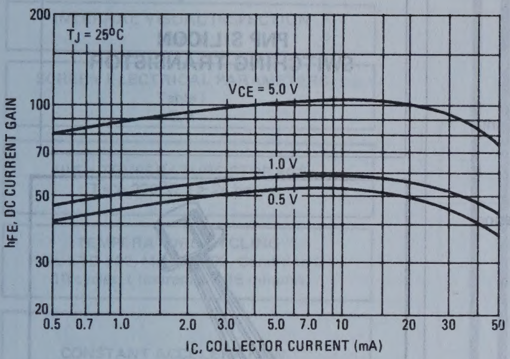


FIGURE 7 – MM4258

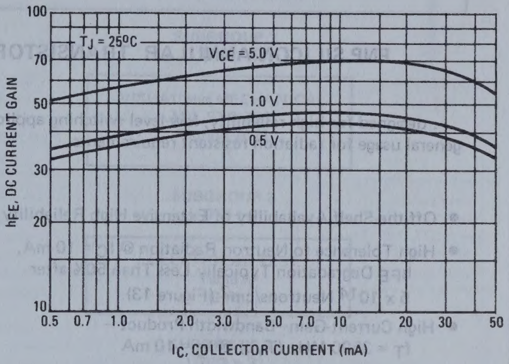
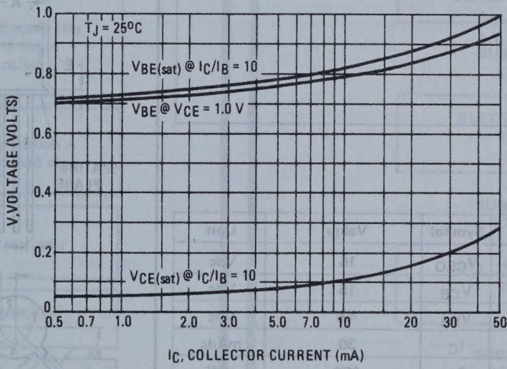


FIGURE 8 – "ON" VOLTAGES



MM4261H (SILICON)

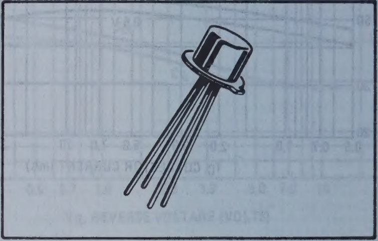
High Reliability Products

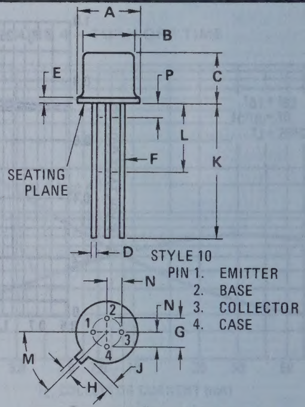
PNP SILICON ANNULAR TRANSISTOR

. . . designed for high reliability, low-level switching applications and general usage for radiation resistant requirements.

- Off-the-Shelf Availability of Extensive High Reliability Processing
- High Tolerance to Neutron Radiation @ I_C = 10 mA, h_{FE} Degradation Typically Less Than 50% after 5×10^{14} Neutrons/cm^2 (Figure 13)
- High Current-Gain—Bandwidth Product — f_T = 3500 MHz (Typ) @ I_C = 10 mA
- Low Input and Output Capacitance — C_{ib} and C_{ob} = 2.5 pF (Max)
- Excellent Current-Mode Performance —
  t_r = 0.5 ns (Typ) @ I_C = 10 mA
  0.9 ns (Typ) @ I_C = 30 mA

PNP SILICON SWITCHING TRANSISTOR





STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

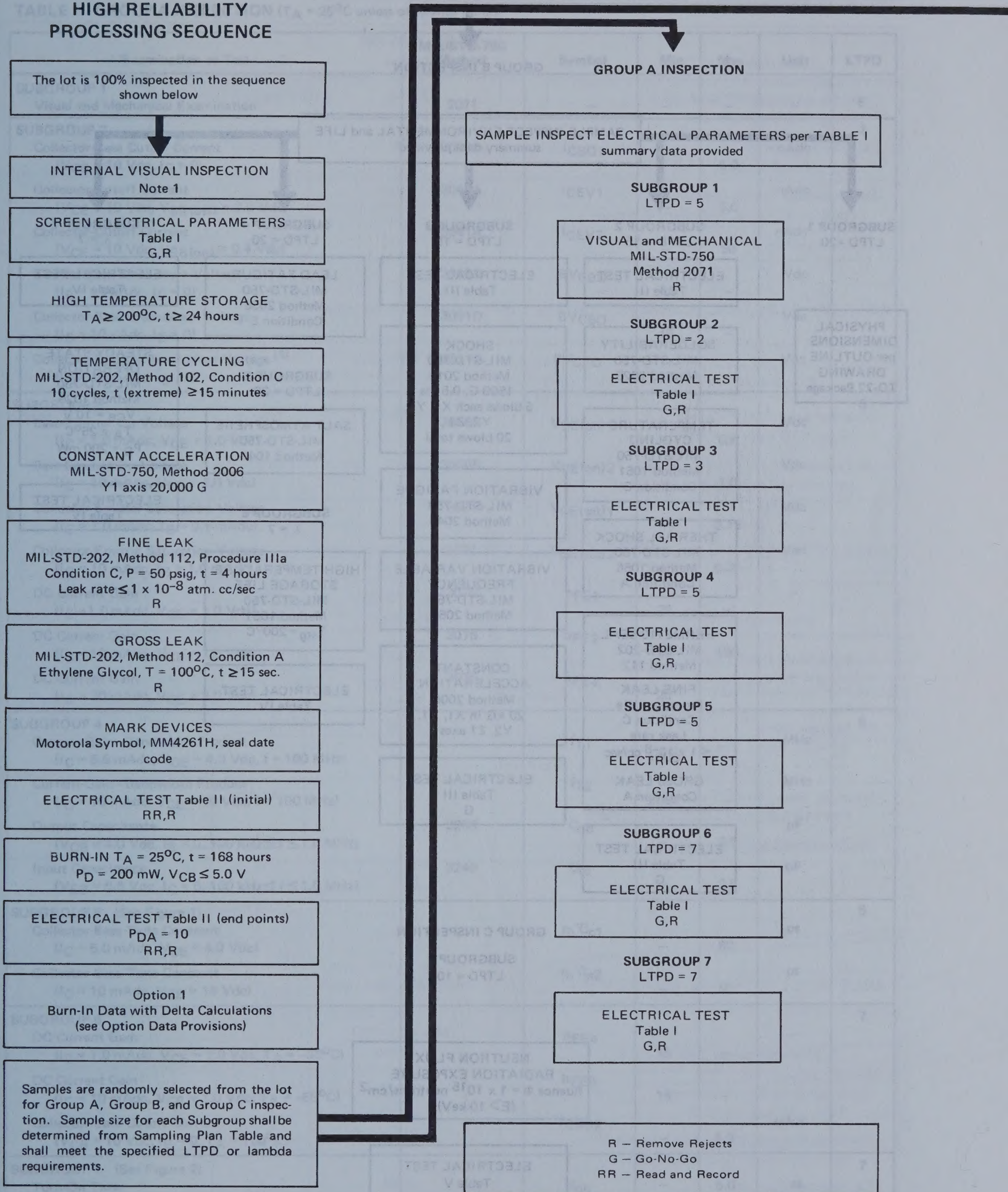
CASE 20-03

TO-72

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

HIGH RELIABILITY PROCESSING SEQUENCE



The lot is 100% inspected in the sequence shown below

INTERNAL VISUAL INSPECTION
Note 1

SCREEN ELECTRICAL PARAMETERS
Table I
G,R

HIGH TEMPERATURE STORAGE
$T_A \geq 200^\circ C$, $t \geq 24$ hours

TEMPERATURE CYCLING
MIL-STD-202, Method 102, Condition C
10 cycles, t (extreme) ≥15 minutes

CONSTANT ACCELERATION
MIL-STD-750, Method 2006
Y1 axis 20,000 G

FINE LEAK
MIL-STD-202, Method 112, Procedure IIIa
Condition C, P = 50 psig, t = 4 hours
Leak rate $\leq 1 \times 10^{-8}$ atm. cc/sec
R

GROSS LEAK
MIL-STD-202, Method 112, Condition A
Ethylene Glycol, $T = 100^\circ C$, $t \geq 15$ sec.
R

MARK DEVICES
Motorola Symbol, MM4261H, seal date code

ELECTRICAL TEST Table II (initial)
RR,R

BURN-IN $T_A = 25^\circ C$, t = 168 hours
$P_D = 200$ mW, $V_{CB} \leq 5.0$ V

ELECTRICAL TEST Table II (end points)
$P_{DA} = 10$
RR,R

Option 1
Burn-In Data with Delta Calculations
(see Option Data Provisions)

Samples are randomly selected from the lot for Group A, Group B, and Group C inspection. Sample size for each Subgroup shall be determined from Sampling Plan Table and shall meet the specified LTPD or lambda requirements.

GROUP A INSPECTION

SAMPLE INSPECT ELECTRICAL PARAMETERS per TABLE I
summary data provided

SUBGROUP 1
LTPD = 5

VISUAL and MECHANICAL
MIL-STD-750
Method 2071
R

SUBGROUP 2
LTPD = 2

ELECTRICAL TEST
Table I
G,R

SUBGROUP 3
LTPD = 3

ELECTRICAL TEST
Table I
G,R

SUBGROUP 4
LTPD = 5

ELECTRICAL TEST
Table I
G,R

SUBGROUP 5
LTPD = 5

ELECTRICAL TEST
Table I
G,R

SUBGROUP 6
LTPD = 7

ELECTRICAL TEST
Table I
G,R

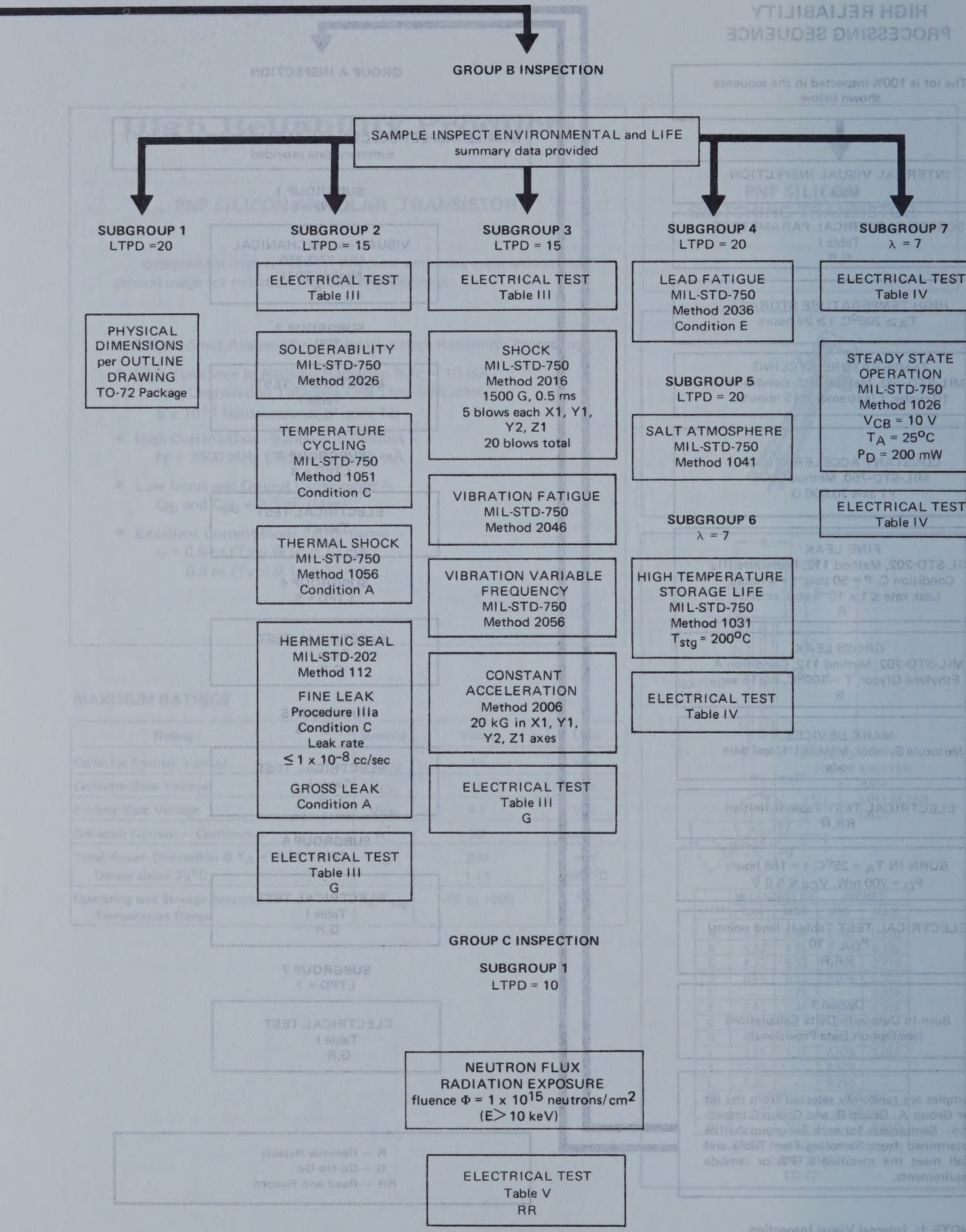
SUBGROUP 7
LTPD = 7

ELECTRICAL TEST
Table I
G,R

R — Remove Rejects
G — Go-No-Go
RR — Read and Record

NOTE 1: Internal Visual Inspection

Each device will be inspected under magnification for defects in material and workmanship which do not comply with Motorola's visual inspection procedures.


GROUP B INSPECTION
SAMPLE INSPECT ENVIRONMENTAL and LIFE summary data provided
SUBGROUP 1
LTPD =20
PHYSICAL DIMENSIONS per OUTLINE DRAWING TO-72 Package
SUBGROUP 2
LTPD = 15
ELECTRICAL TEST Table III
SOLDERABILITY MIL-STD-750 Method 2026
TEMPERATURE CYCLING MIL-STD-750 Method 1051 Condition C
THERMAL SHOCK MIL-STD-750 Method 1056 Condition A
HERMETIC SEAL MIL-STD-202 Method 112
FINE LEAK Procedure IIIa Condition C Leak rate ≤ 1 x 10^{-8} cc/sec
GROSS LEAK Condition A
ELECTRICAL TEST Table III G
SUBGROUP 3
LTPD = 15
ELECTRICAL TEST Table III
SHOCK MIL-STD-750 Method 2016 1500 G, 0.5 ms 5 blows each X1, Y1, Y2, Z1 20 blows total
VIBRATION FATIGUE MIL-STD-750 Method 2046
VIBRATION VARIABLE FREQUENCY MIL-STD-750 Method 2056
CONSTANT ACCELERATION Method 2006 20 kG in X1, Y1, Y2, Z1 axes
ELECTRICAL TEST Table III G
SUBGROUP 4
LTPD = 20
LEAD FATIGUE MIL-STD-750 Method 2036 Condition E
SUBGROUP 5
LTPD = 20
SALT ATMOSPHERE MIL-STD-750 Method 1041
SUBGROUP 6
λ = 7
HIGH TEMPERATURE STORAGE LIFE MIL-STD-750 Method 1031 T_{stg} = 200°C
ELECTRICAL TEST Table IV
SUBGROUP 7
λ = 7
ELECTRICAL TEST Table IV
STEADY STATE OPERATION MIL-STD-750 Method 1026 V_{CB} = 10 V T_A = 25°C P_D = 200 mW
ELECTRICAL TEST Table IV
GROUP C INSPECTION
SUBGROUP 1
LTPD = 10
NEUTRON FLUX RADIATION EXPOSURE fluence Φ = 1 x 10^{15} neutrons/cm^2 (E > 10 keV)
ELECTRICAL TEST Table V RR

G — Go-No-Go

RR — Read and Record

TABLE I: GROUP A INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit	LTPD
SUBGROUP 1						5
Visual and Mechanical Examination	2071	—	—	—	—	
SUBGROUP 2						2
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	—	5.0	nAdc	
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	3041A	I_{CEV1}	—	5.0	nAdc	
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{EB(on)}$ = 0.4 Vdc)	3041A	I_{CEV2}	—	50	nAdc	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	3026D	BV_{EBO}	4.5	—	Vdc	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	3001D	BV_{CBO}	15	—	Vdc	
Collector-Emitter Breakdown Voltage [(1)] (I_C = 10 mAdc, I_B = 0)	3011D	BV_{CEO}	15	—	Vdc	
SUBGROUP 3						3
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	3066B	$V_{BE(on)1}$	—	0.8	Vdc	
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3066B	$V_{BE(on)2}$	—	1.0	Vdc	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	3071	$V_{CE(sat)1}$	—	0.15	Vdc	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	3071	$V_{CE(sat)2}$	—	0.35	Vdc	
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE1}	25	—	—	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	30	150	—	
DC Current Gain (I_C = 30 mAdc, V_{CE} = 2.0 Vdc)	3076	h_{FE3}	20	—	—	
SUBGROUP 4						5
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)		f_{T1}	1500	—	MHz	
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_{T2}	2000	—	MHz	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	3236	C_{ob}	—	2.5	pF	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	3240	C_{ib}	—	2.5	pF	
SUBGROUP 5 (See Figure 1)						5
Collector-Base Time Constant (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc)		$r_b'C_{c1}$	—	60	ps	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 10 Vdc)		$r_b'C_{c2}$	—	50	ps	
SUBGROUP 6						7
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)		h_{FE4}	15	—	—	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = −55°C)		h_{FE5}	15	—	—	
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		I_{CBO2}	—	5.0	μAdc	
SUBGROUP 7 (See Figure 2)						7
Turn-On Time		t_{on}	—	5.0	ns	
Turn-Off Time		t_{off}	—	5.0	ns	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TABLE II: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	—	5.0	nAdc
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	30	150	—
Collector-Base Cutoff Current 100% or 5.0 nAdc whichever is greater		ΔI_{CBO1}	—	—	—
DC Current Gain		Δh_{FE2}	—	±20%	—

TABLE III: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	—	5.0	nAdc
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	30	150	—

TABLE IV: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

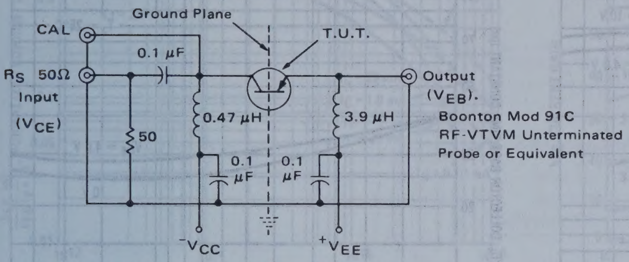
Examination or Test		MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	Initial End Point	3036D	I_{CBO1}	— —	5.0 10	nAdc
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	Initial End Point	3076	h_{FE2}	30 20	150 180	—
Collector-Base Cutoff Current 100% or 5.0 nAdc whichever is greater			ΔI_{CBO1}	—	—	—
DC Current Gain			Δh_{FE2}	—	±20%	—

TABLE V: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} =10 Vdc, I_E = 0)	3036D	I_{CBO1}	—	10	µAdc
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	3071	$V_{CE(sat)2}$	—	0.5	Vdc
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	12	—	—

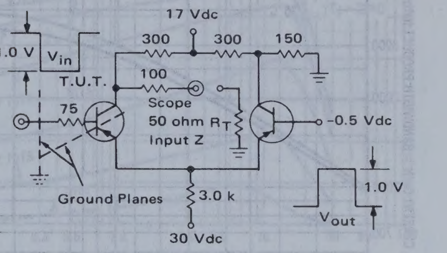
(1) Pulse Test: Pulse Width $\leq$ 300 µs, Duty Cycle $\leq$ 2.0%.

FIGURE 1 – COLLECTOR-BASE TIME CONSTANT TEST CIRCUIT


Ground Plane
CAL
T.U.T.
0.1 μF
R_S 50Ω
Input
(V_{CE})
Output
(V_{EB}).
0.47 μH
3.9 μH
Boonton Mod 91C
RF-VTVM Unterminated
Probe or Equivalent
50
0.1 μF
0.1 μF
$-V_{CC}$
$+V_{EE}$

1. With transistor under test removed from socket, set input level at "CAL" jack to 500 mV at 31.8 MHz. Insert transistor in socket.
2. After putting VTVM probe on "OUT" jack, adjust bias on transistor under test.
3. Reading on VTVB in millivolts multiplied by 10 equals $r_b'C_c$

FIGURE 2 – TURN-ON TIME AND TURN-OFF TIME TEST CIRCUIT


17 Vdc
300
300
150
1.0 V
V_{in}
T.U.T.
100
Scope
50 ohm R_T
Input Z
75
-0.5 Vdc
Ground Planes
3.0 k
30 Vdc
1.0 V
V_{out}

The test circuit is designed to simulate a series of cascaded identical circuits with input Z equal to output Z.

FIGURE 3 – DC CURRENT GAIN

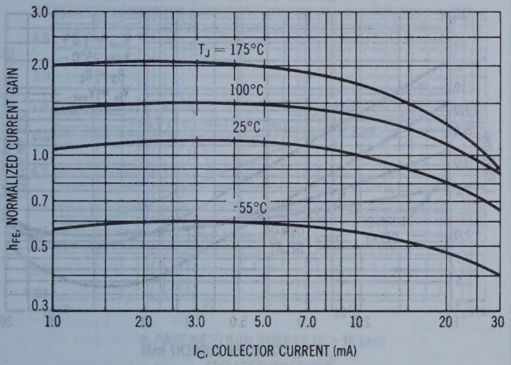
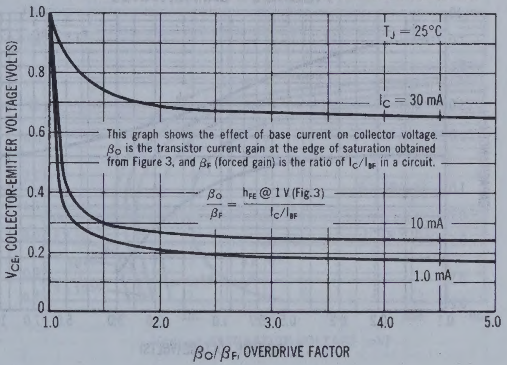


FIGURE 4 – COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector voltage. β_O is the transistor current gain at the edge of saturation obtained from Figure 3, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\text{ V (Fig.3)}}{I_C/I_{BF}}$$

FIGURE 5 – "ON" VOLTAGES

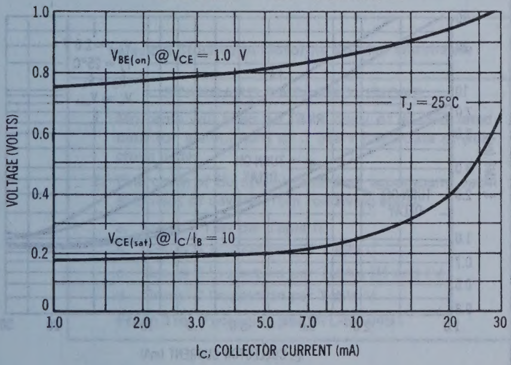


FIGURE 6 – TEMPERATURE COEFFICIENTS

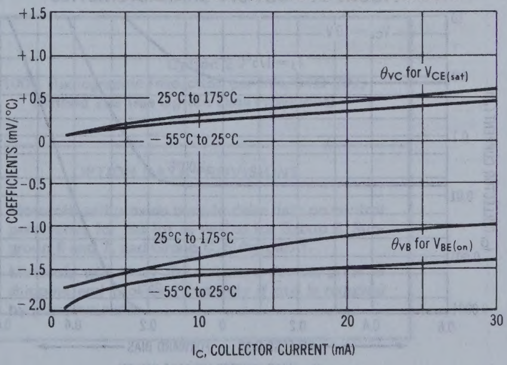


FIGURE 7 — CURRENT-GAIN—BANDWIDTH PRODUCT

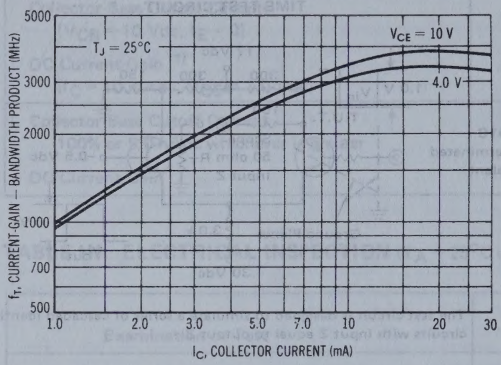


FIGURE 8 — COLLECTOR-BASE TIME CONSTANT

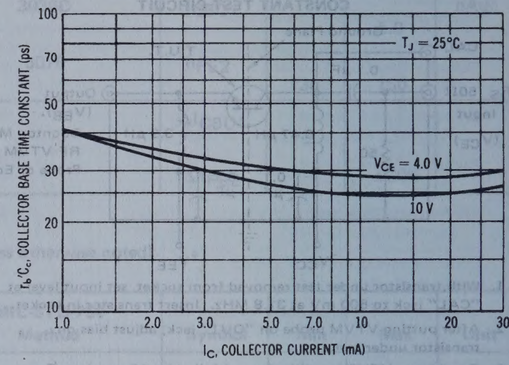


FIGURE 9 — CAPACITANCE

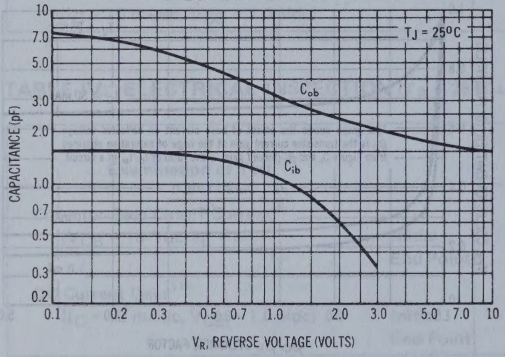


FIGURE 10 — SWITCHING TIMES

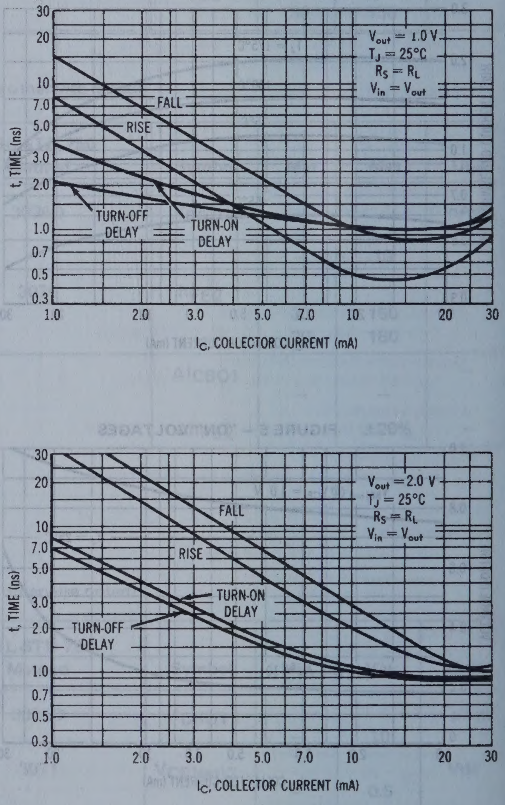


FIGURE 11 — CUT-OFF CHARACTERISTICS

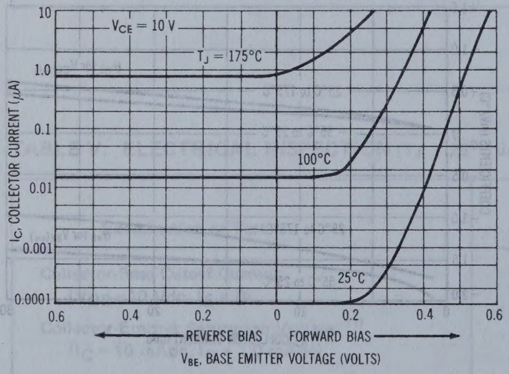


FIGURE 12 – NORMALIZED DC CURRENT GAIN versus FAST NEUTRON DOSAGE

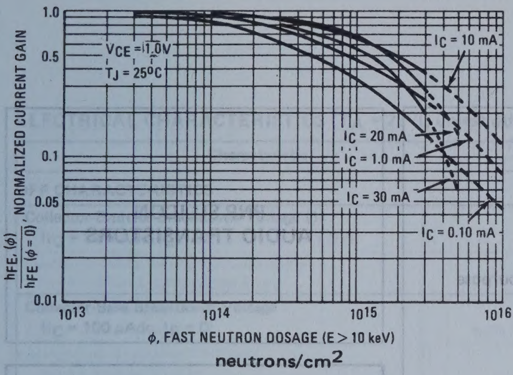


FIGURE 13 – TYPICAL DC CURRENT GAIN versus FAST NEUTRON DOSAGE

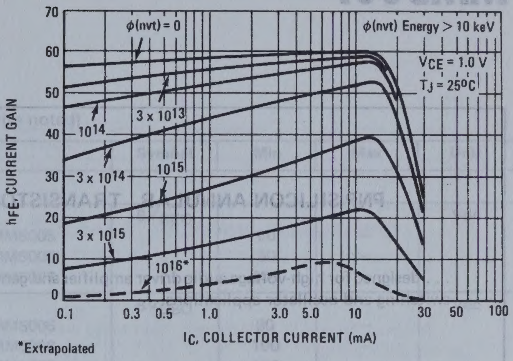


FIGURE 14 – COLLECTOR-BASE LEAKAGE CURRENT versus FAST NEUTRON DOSAGE

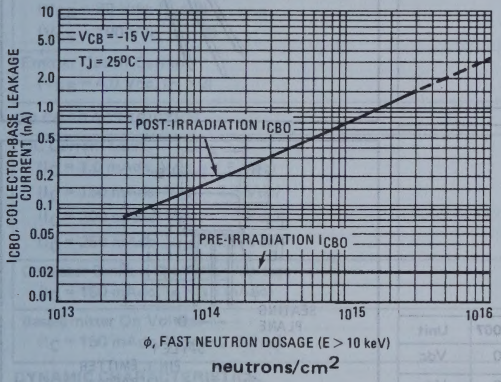
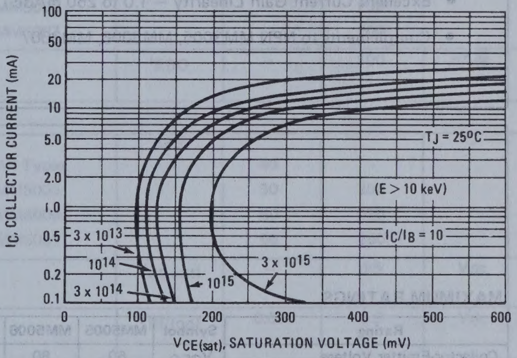


FIGURE 15 – TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE versus FAST NEUTRON DOSAGE



Devices Stocked in Motorola Bonded Warehouse

STANDARD DATA PROVISIONS

1. Motorola will keep on file 1 copy of all associated data for a minimum of 3 years from date of purchase order.
2. One copy of Summary data shall accompany each shipment of devices from following steps.
   - a. Burn-In Test per Table II
   - b. Group A Inspection per Table I
   - c. Group B Inspection per Tables III and IV
   - d. Group C Inspection per Table V

Foam Tray Packaging per MIL-S-19491

Option 2
100% Radiographic Inspection per MIL-STD-202, Method 209 (see Option Data Provisions)

OPTION DATA PROVISIONS

1. Motorola will provide burn-in delta data on control parameters for the lot as well as for Group B, Subgroup 6 and 7, and Group C, Subgroup 1.
2. Motorola will X-ray the serialized devices prior to shipping and provide films only if this is required by purchase order.

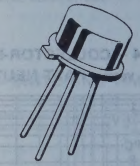
MM5005 (SILICON)
MM5006
MM5007

PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-voltage audio driver amplifier and general purpose switching and oscillator applications.

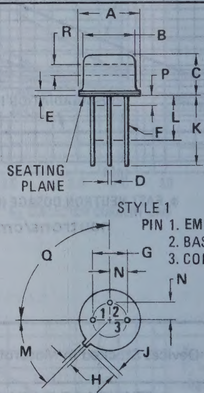
- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 100 Vdc (Min) @ I_C = 10 mAdc (MM5007)
- Low Output Capacitance — C_{ob} = 20 pF (Max) @ V_{CB} = 10 Vdc
- Excellent Current Gain Linearity — 1.0 to 250 mAdc
- Complements to NPN MM3005, MM3006, MM3007

PNP SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MM5005	MM5006	MM5007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous	I_C	← 2.0 →			Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 1.5 → ← 8.57 →			Watts mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 8.0 → ← 45.7 →			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}			Vdc
(I_C = 10 mAdc, I_B = 0)	MM5005		60	–	
	MM5006		80	–	
	MM5007		100	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	MM5005		80	–	
	MM5006		100	–	
	MM5007		120	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 60 Vdc, I_E = 0)	MM5005		–	200	
(V_{CB} = 80 Vdc, I_E = 0)	MM5006		–	200	
(V_{CB} = 100 Vdc, I_E = 0)	MM5007		–	200	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 2.5 Vdc)	All Types		40	–	
(I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	MM5005		50	250	
(I_C = 200 mAdc, V_{CE} = 2.5 Vdc)	MM5006		50	250	
(I_C = 250 mAdc, V_{CE} = 2.5 Vdc)	MM5007		50	250	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)		$V_{BE(on)}$	0.65	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	pF

(1) Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.

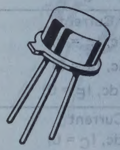
MM5189 (SILICON)

NPN SILICON HIGH CURRENT AMPLIFIER AND CORE DRIVER TRANSISTOR

NPN SILICON ANNULAR TRANSISTOR

. . . designed for use in high-current, high speed switching, and core driver applications.

- Collector-Emitter Breakdown Voltage — BV_{CES} = 55 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.29 Vdc (Typ) @ I_C = 1.0 Adc
- High Current-Gain—Bandwidth Product — f_T = 350 MHz (Typ) @ I_C = 50 mAdc
- Fast Switching Time @ I_C = 1.0 Adc
  - t_{on} = 16 ns (Typ)
  - t_{off} = 28 ns (Typ)
- Device Electrically Similar to 2N5189



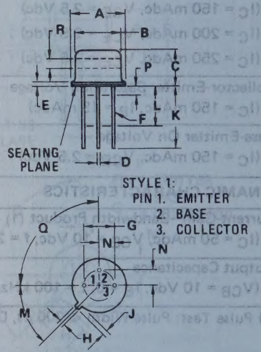
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	55	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

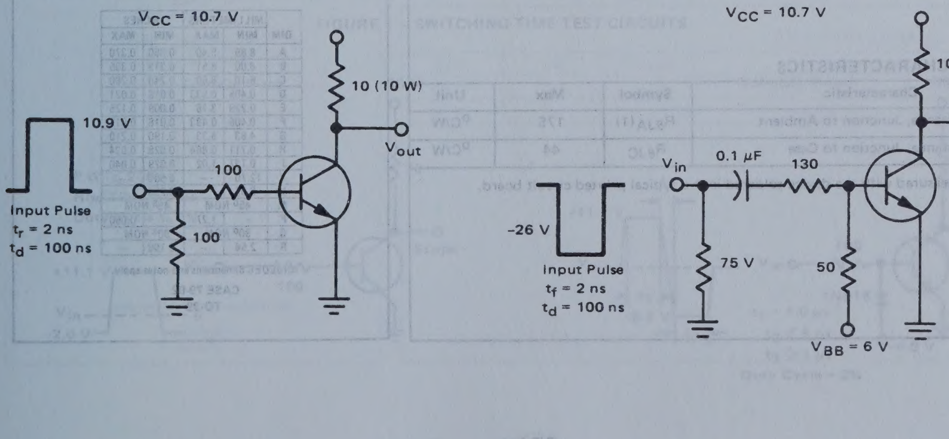
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, V_{BE} = 0)	BV_{CES}	55	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 55 Vdc, V_{BE} = 0)	I_{CES}	–	–	100	µAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	–	–	100	µAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	µAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	20	35	–	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	–	0.29	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	–	0.94	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	–	350	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	7.3	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	72	–	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	–	16	40	ns
Turn-Off Time	t_{off}	–	28	70	ns

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle ⩽2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



V_{CC} = 10.7 V
10 (10 W)
10.9 V
V_{out}
100
100
Input Pulse
t_r = 2 ns
t_d = 100 ns
V_{CC} = 10.7 V
10 (10 W)
V_{out}
V_{in}
0.1 µF
130
–26 V
Input Pulse
t_f = 2 ns
t_d = 100 ns
75 V
50
V_{BB} = 6 V

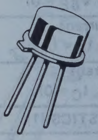
MM5262 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for use in high-current, high-speed current switching and core driver applications.

- Collector-Emitter Breakdown Voltage — BV_{CES} = 60 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.29 Vdc (Typ) @ I_C = 1.0 Adc
- High Current-Gain—Bandwidth Product — f_T = 350 MHz (Typ) @ I_C = 50 mAdc
- Fast Switching Times @ I_C = 1.0 Adc —
  t_{on} = 16 ns (Typ)
  t_{off} = 28 ns (Typ)

NPN SILICON HIGH CURRENT AMPLIFIER AND CORE DRIVER TRANSISTOR



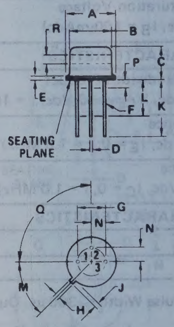
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Collector-Base Voltage	V_{CB}	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	44	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

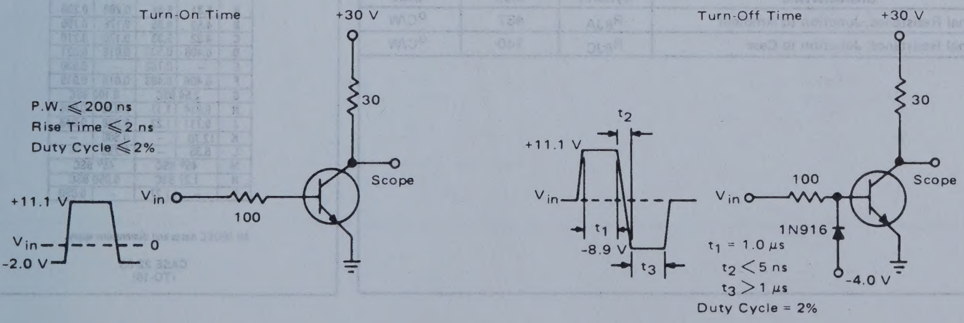
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	75	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	–	–	10	μAdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	–	–	100	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		35	100	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		40	65	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		25	35	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	–	0.29	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc	$V_{BE(sat)}$	–	0.94	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	–	350	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	7.3	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	72	–	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	t_{on}	–	16	30	ns
Turn-Off Time	t_{off}	–	28	60	ns

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS


Turn-On Time
+30 V
30
Scope
P.W. ⩽200 ns
Rise Time ⩽2 ns
Duty Cycle ⩽2%
+11.1 V
V_{in}
0
-2.0 V
V_{in}
100
Turn-Off Time
+30 V
30
Scope
t_2
+11.1 V
V_{in}
t_1
-8.9 V
t_3
V_{in}
100
1N916
t_1 = 1.0 μs
t_2 < 5 ns
t_3 > 1 μs
-4.0 V
Duty Cycle = 2%

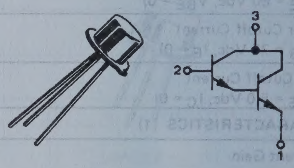
MM6427 (SILICON)

NPN SILICON ANNULAR DARLINGTON TRANSISTOR

. . . designed for use as high-gain amplifiers for audio, chroma, and control circuits; drivers for displays, lamps, buzzers and solenoids.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- DC Current Gain specified @ 10 mAdc and 100 mAdc
- Monolithic Construction

NPN SILICON DARLINGTON TRANSISTOR

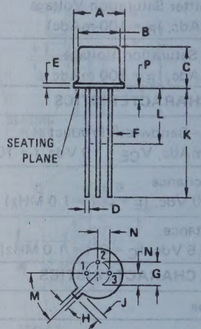


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	12	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	375 2.14	mW W/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 7.15	Watts W/°C
Operating and Storage Junction	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	467	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	140	°C/W



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

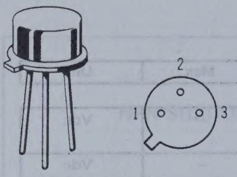
CASE 22-03
(TO-18)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	12	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		5000	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		10,000	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
High Frequency Current Gain (1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	h_{fe}	1.25	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	15	pF

(1) Pulse Test: Pulse Width ⩽300 μs; Duty Cycle ⩽2.0%.

MM8000 (SILICON)
MM8001



CASE 79
(TO-39)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon high-frequency transistor designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

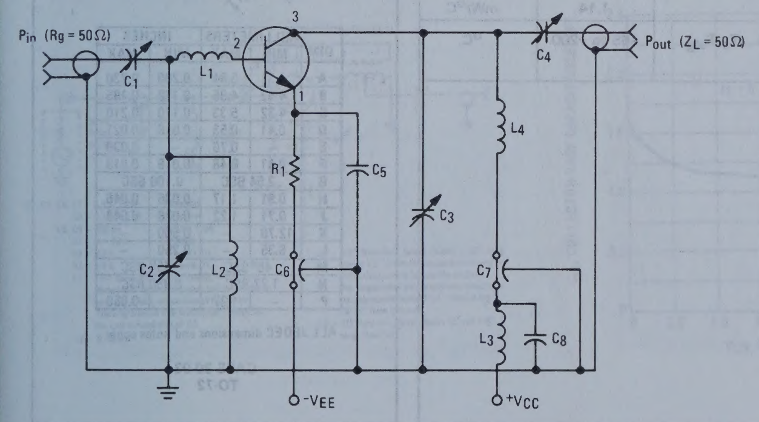
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	3.5	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)		I_{CEO}	-	-	20	µAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)		h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000 MM8001	f_T	550 700	- -	- -	MHz
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000 MM8001		700 900	- -	- -	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000 MM8001		700 900	- -	- -	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	-	3.5	pF
Noise Figure (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	Figure 1 Test Circuit	NF	-	2.7	-	dB
FUNCTIONAL TESTS						
Common-Emitter Amplifier Power Gain (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	Figure 1 Test Circuit	G_{pe}	-	11.4	-	dB

FIGURE 1 – 200 MHz TEST CIRCUIT



C1, C2, C3: 1.0 – 30 pF
C4: 1.0 – 20 pF
C5: 10,000 pF
C6, C7: 1000 pF
C8: 0.01 µF

L1: 4-1/2 turns, No. 22 AWG wire, 3/16" I.D.
L4: 3-1/2 turns, No. 22 AWG wire, 3/16" I.D.
L2, L3: 0.82 µH RFC
R1: 240 ohms, 2 watts

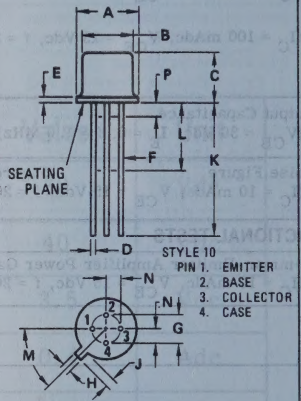
MM8006 (SILICON)
MM8007

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in high-gain, low-noise, small-signal amplifiers in military and industrial equipment. Suitable for use in video wideband and general high-frequency amplifier applications of 50 to 1000 MHz.

- Low Noise Figure –
  NF = 2.2 dB (Typ) @ f = 200 MHz – MM8006
- High Power Gain –
  G_{pe} = 25 dB (Typ) @ f = 200 MHz – MM8006
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Min) @ I_C = 5.0 mAdc

NPN SILICON
RF SMALL-SIGNAL
TRANSISTORS



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

MAXIMUM RATINGS

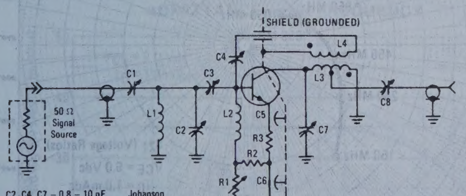
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	20	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	200	mW
Derate above 25°C		1.14	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)		BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E - 0.01 mAdc, I_C = 0)		BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)		I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)		h_{FE}	25	–	–	–
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)		f_T	1000	–	3500	MHz
Collector-Base Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)		C_{cb}	–	1.1	1.5	pF
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)		$r_b'C_c$	–	5.0	–	ps
Noise Figure		NF				dB
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 60 MHz)	MM8006		–	1.5	–	
	MM8007		–	1.9	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	MM8006		–	2.2	–	
	MM8007		–	2.7	–	
†(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	MM8006		–	–	3.8	
	MM8007		–	–	5.0	
FUNCTIONAL TEST						
†Common-Emitter Amplifier Power Gain		G_{pe}				dB
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 60 MHz)	Both Types		–	30	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	MM8006		–	25	–	
	MM8007		–	20	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	MM8006		14	–	–	
	MM8007		12	–	–	

†Tuned for minimum noise.

FIGURE 1 — POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1, C2, C4, C7	0.8 – 10 pF	Johanson
C8	0.5 – 3.5 pF	Johanson
C3, C5	500 pF	Button Type
R1	0 – 10 k	Trimpot
R2	2.7 k	1/4 watt 5%
R3	1.0 k	1/4 watt 5%

L1 – 1/4" Brass Rod, Solder Plated, 1-1/8" long. Placed 5/8" from the socket and in parallel with the shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C2.

L2 – 0.22 μH

L3 – 1/4" Brass Rod, Solder Plated, 1-1/2" long. Placed 1/2" from the socket and in parallel with shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C7. Output tap is 15/16" from ground.

L4 – 1/2 Turn #16, 5/16" above L3 and 5/8" long, (over L3).

FIGURE 2 — COLLECTOR-BASE CAPACITANCE versus VOLTAGE

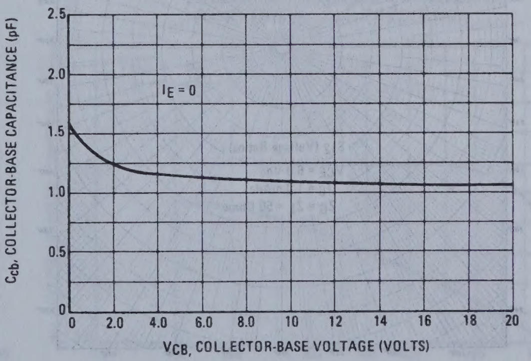


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

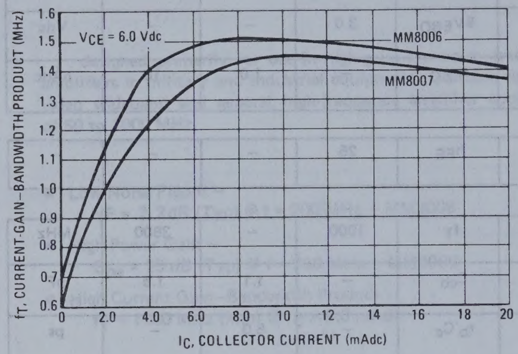


FIGURE 4 – S_{11} AND S_{22}

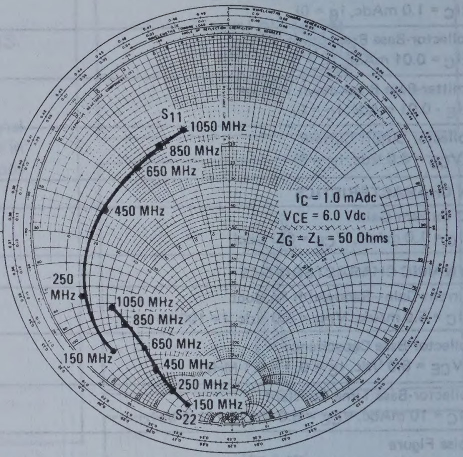


FIGURE 5 – S_{12}

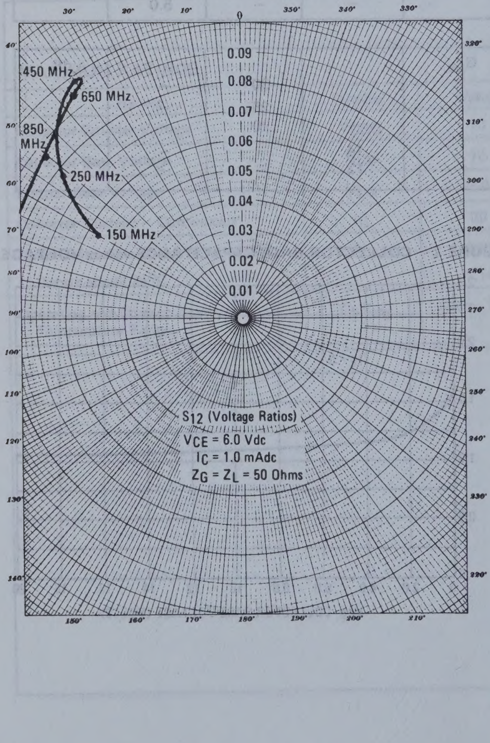


FIGURE 6 – S_{21}

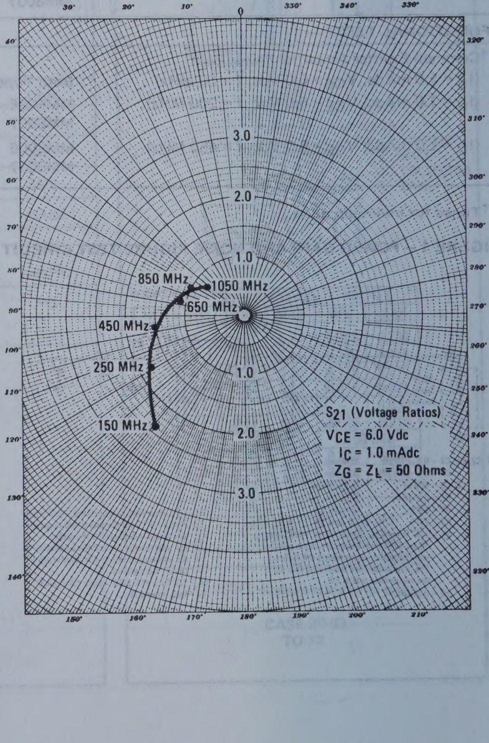


FIGURE 7 – NOISE FIGURE versus FREQUENCY

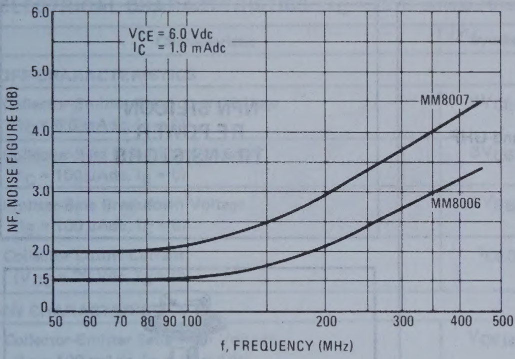


FIGURE 8 – POWER GAIN versus FREQUENCY

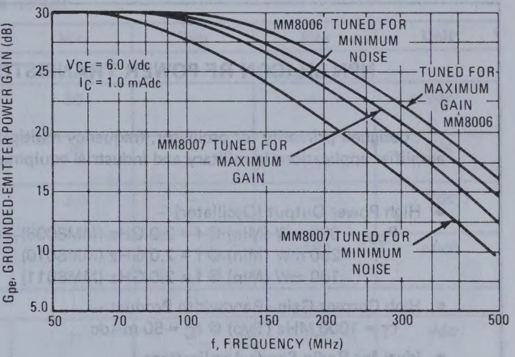


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

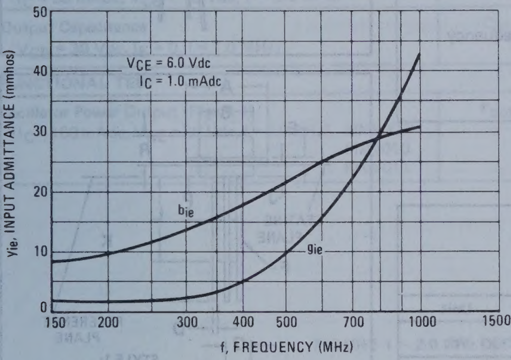


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

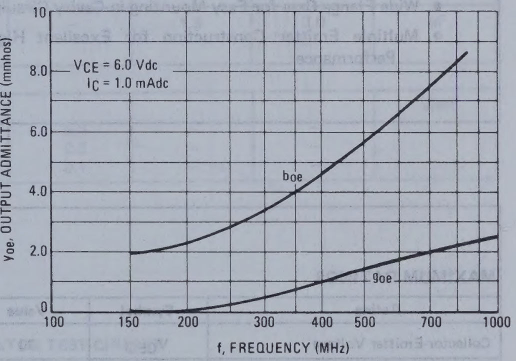


FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

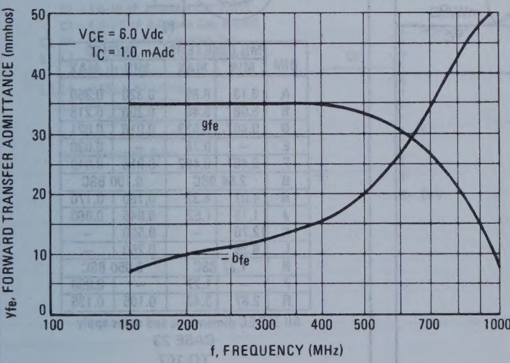
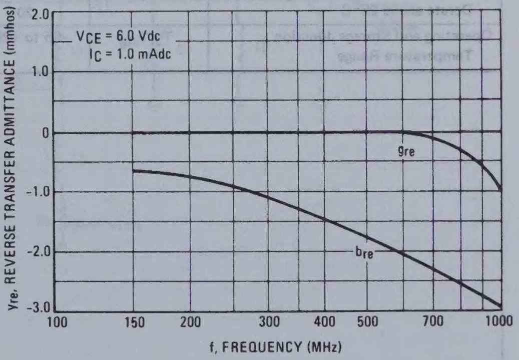


FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



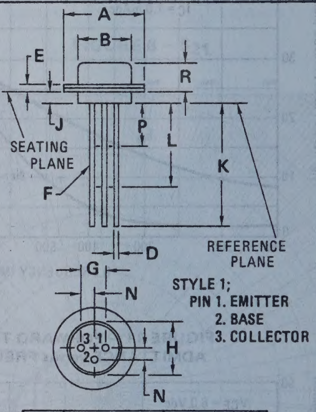
MM8008 (SILICON)
MM8010
MM8011

NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for oscillator, frequency multiplier, and UHF amplifier applications in military and industrial equipment.

- High Power Output (Oscillator) –
  P_{out} = 300 mW (Min) @ f = 2.0 GHz (MM8008)
  200 mW (Min) @ f = 2.0 GHz (MM8010)
  100 mW (Min) @ f = 2.0 GHz (MM8011)
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Typ) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications –
  P_{out} (Oscillator) = 550 mW (Typ) @ f = 1.68 GHz (MM8008)
  450 mW (Typ) @ f = 1.68 GHz (MM8010)
  300 mW (Typ) @ f = 1.68 GHz (MM8011)
- Wide Flange Case for Easy Mounting in Cavity Circuits
- Multiple Emitter Construction for Excellent High-Frequency Performance

NPN SILICON RF POWER TRANSISTORS



STYLE 1;
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.13	8.89	0.320	0.350
B	5.08	5.46	0.200	0.215
D	0.407	0.533	0.016	0.021
E	–	0.76	–	0.030
F	0.407	0.482	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	4.07	4.32	0.160	0.170
J	1.15	1.52	0.045	0.060
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050
R	2.67	3.42	0.105	0.135

All JEDEC dimensions and notes apply
CASE 23
TO-107

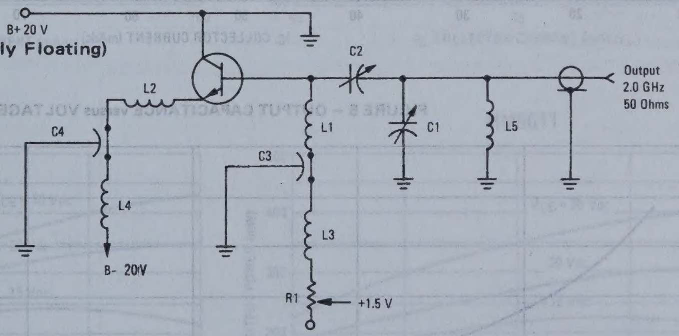
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_C = 25^\circ C$ Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	35	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	–	1100	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.3	3.0	pF
FUNCTIONAL TEST					
Oscillator Power Output (Figure 1) (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 2.0 GHz)	P_{out}				Watt
MM8008		0.3	–	–	
MM8010		0.2	–	–	
MM8011		0.1	–	–	

FIGURE 1 – 2.0 GHz OSCILLATOR TEST CIRCUIT



C1 – 1.0-10 pF Johanson Cap. #3901
C2 – 4.0-6.0 pF Johanson Cap. # 4640
C3, C4 – 500 pF Button Feedthru Cap.
L1, L2 – Microstrip Line 1.03" Long and 0.073" Wide
L3, L4 – 0.68 μH RF Choke
L5 – Microstrip 0.620" Long and 0.078" Wide
R1 – 2.0 k ohms Pot (Miniature)
1/16" Microstrip Board

FIGURE 2 – TOP VIEW – 2.0 GHz OSCILLATOR TEST CIRCUIT

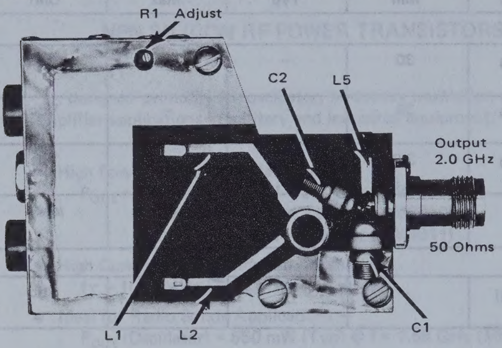

R1 Adjust
C2
L5
Output
2.0 GHz
50 Ohms
L1
L2
C1

FIGURE 3 – SIDE VIEW – 2.0 GHz OSCILLATOR TEST CIRCUIT

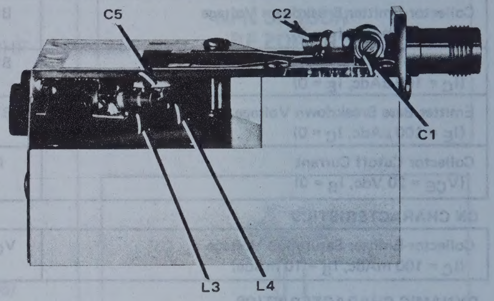

C5
C2
C1
L3
L4

FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

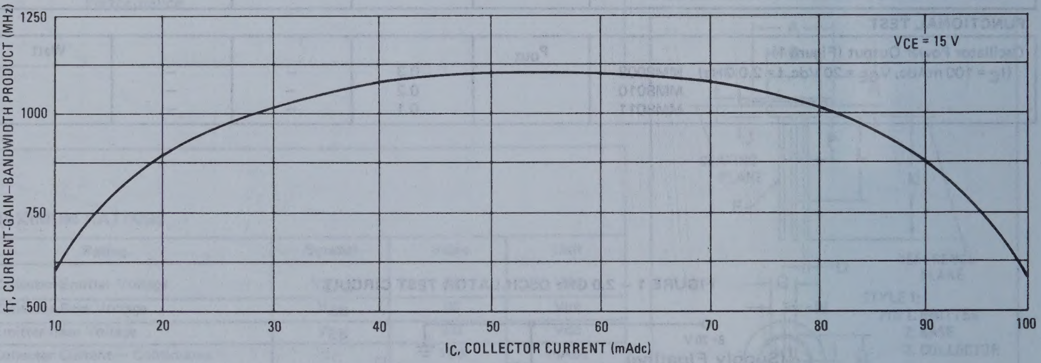
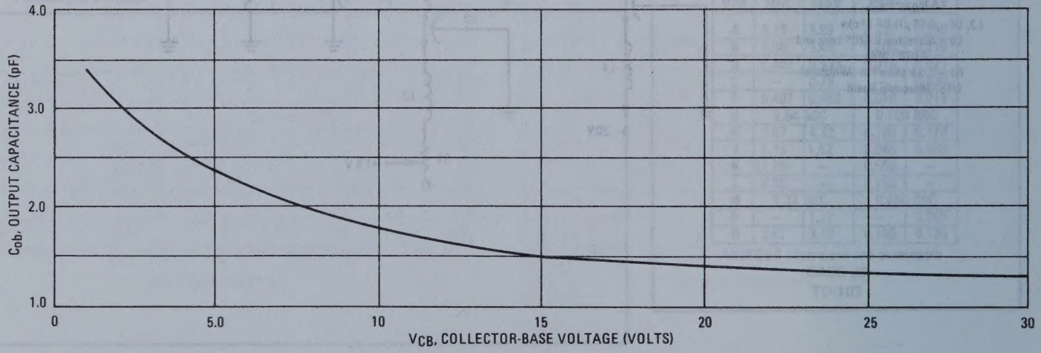


FIGURE 5 – OUTPUT CAPACITANCE versus VOLTAGE



OSCILLATOR OUTPUT POWER versus CURRENT
(SEE FIGURE 1 FOR TEST CIRCUIT)

FIGURE 6 – f = 2.0 GHz

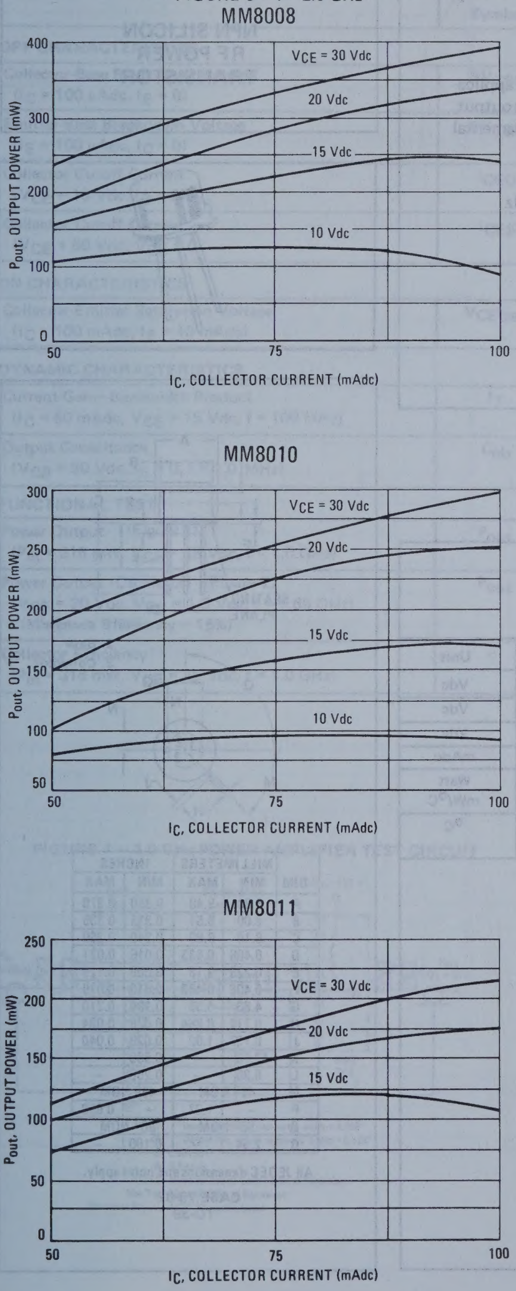
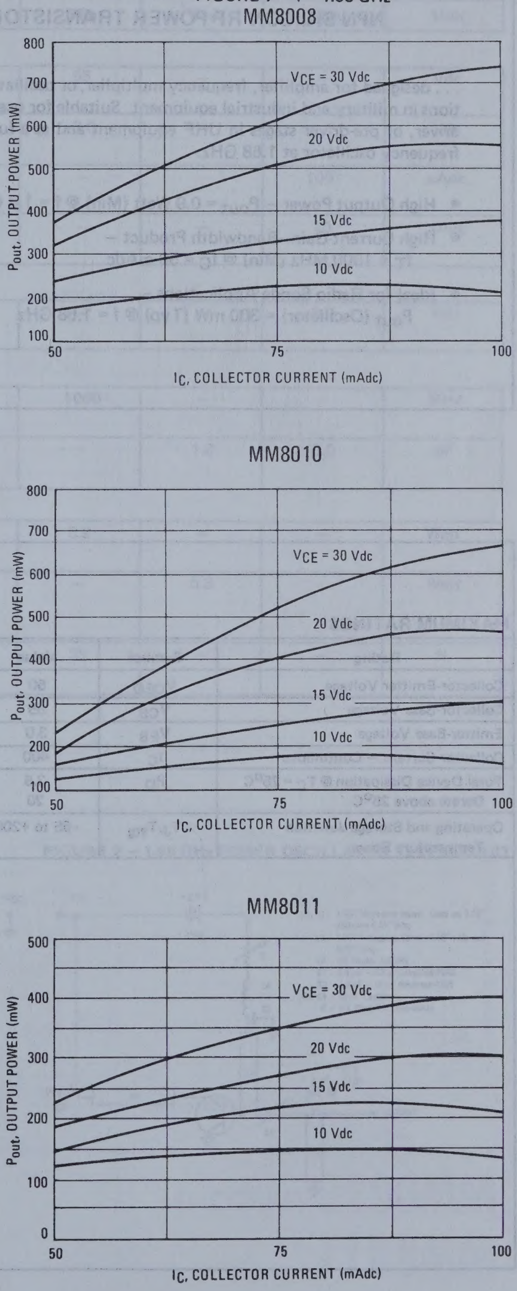


FIGURE 7 – f = 1.68 GHz



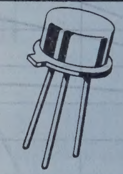
MM8009 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in UHF equipment and as a fundamental frequency oscillator at 1.68 GHz.

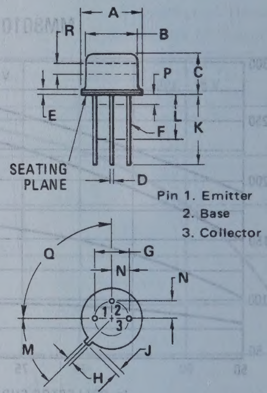
- High Output Power – P_{out} = 0.9 Watt (Min) @ f = 1.0 GHz
- High Current-Gain–Bandwidth Product – f_T = 1000 MHz (Min) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications – P_{out} (Oscillator) = 300 mW (Typ) @ f = 1.68 GHz

NPN SILICON
RF POWER
TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25°C	P_D	3.5 20	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

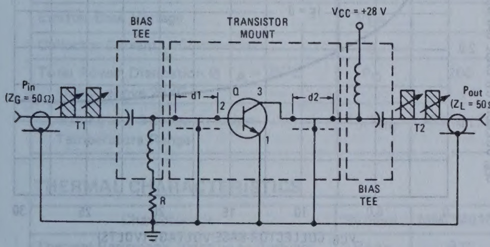
All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted)

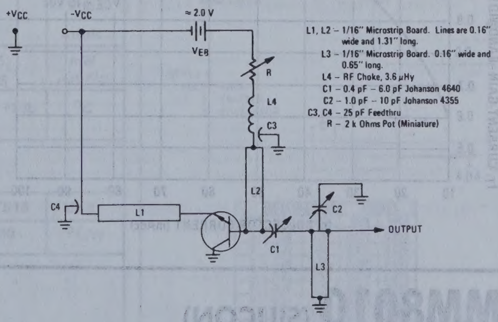
	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage ($I_C = 100\ \mu Adc$, $I_E = 0$)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu Adc$, $I_C = 0$)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current ($V_{CE} = 15$ Vdc, $I_B = 0$)	I_{CEO}	–	–	100	μAdc
Collector Cutoff Current ($V_{CE} = 50$ Vdc, $V_{BE} = 0$)	I_{CES}	–	–	10	μAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, f = 100 MHz)	f_T	1000	–	–	MHz
Output Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	–	1.8	3.0	pF
FUNCTIONAL TEST					
Power Output (Figure 1) ($P_{in} = 316$ mW, $V_{CE} = 28$ Vdc, f = 1.0 GHz)	P_{out}	0.9	–	–	Watt
Power Output (Oscillator) (Figure 2) ($V_{CE} = 20$ Vdc, $V_{EB} = 1.5$ Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	–	0.3	–	Watt
Collector Efficiency ($P_{in} = 316$ mW, $V_{CE} = 28$ Vdc, f = 1.0 GHz)	η	35	–	–	%

FIGURE 1 – 1.0 GHz POWER AMPLIFIER TEST CIRCUIT



d1: 1″ Input line, center conductor width = 0.280″
d2: 1″ Output line, center conductor width = 0.125″
Q: 2N5108
R: 3.9 ohms
T1, T2: Microlab Double Stub Tuner, or Equivalent
Bias Tee: Microlab 08N, or Equivalent
Transistor Mount: 1/32″ Microstrip board

FIGURE 2 – 1.68 GHz POWER OSCILLATOR TEST CIRCUIT



L1, L2 – 1/16″ Microstrip Board. Lines are 0.16″ wide and 1.31″ long.
L3 – 1/16″ Microstrip Board. 0.16″ wide and 0.65″ long.
L4 – RF Choke, 3.6 μHy
C1 – 0.4 pF – 6.0 pF Johanson 4640
C2 – 1.0 pF – 10 pF Johanson 4355
C3, C4 – 25 pF Feedthru
R – 2 k Ohms Pot (Miniature)

FIGURE 3 – POWER OUTPUT versus POWER INPUT

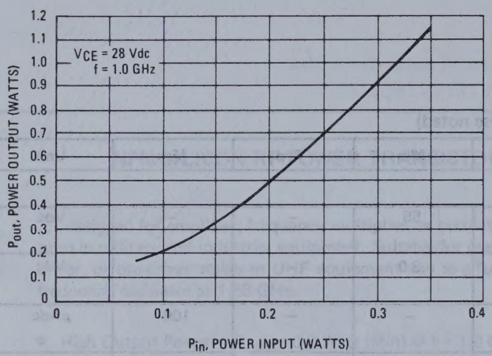


FIGURE 4 – POWER OUTPUT versus FREQUENCY

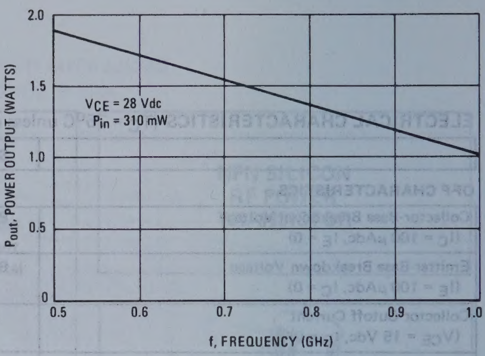


FIGURE 5 – POWER OUTPUT versus VOLTAGE

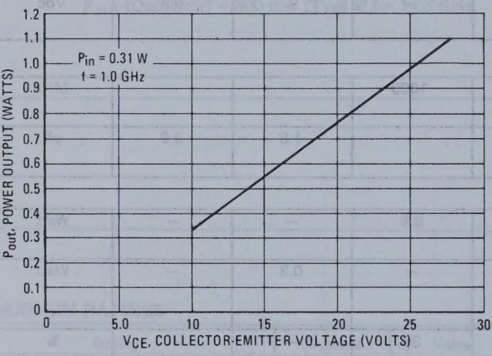


FIGURE 6 – OSCILLATOR POWER OUTPUT versus CURRENT

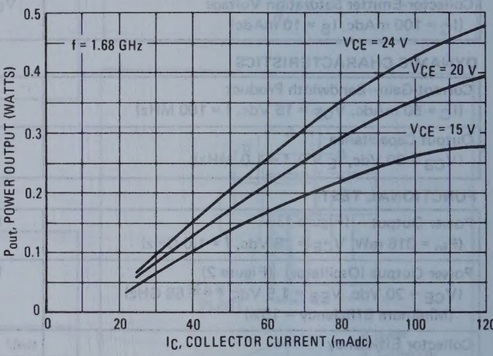


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

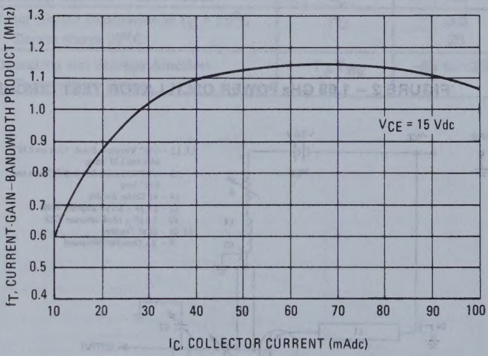
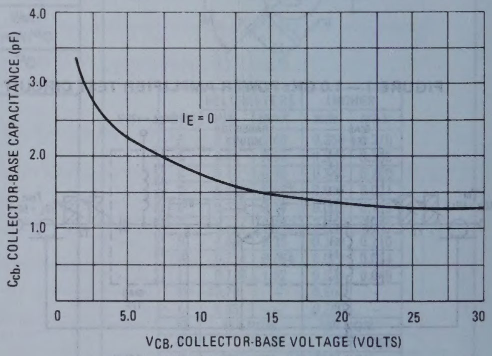


FIGURE 8 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE



MM8010 (SILICON)
MM8011

For Specifications, See MM8008 Data.

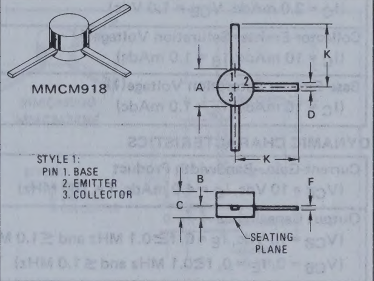
MMCM918 (SILICON)
MMT918

NPN SILICON ANNULAR TRANSISTORS

. . . designed for VHF and UHF amplifier, mixer and oscillator applications.

- Space Saving Micro-Miniature Packages
- High Current-Gain–Bandwidth Product – f_T = 600 MHz (Min)
- Low Capacitance – C_{ob} = 1.7 pF (Max)
- MMT918 – One-Piece, Injection-Molded Package for High Reliability
  MMCM918 – Ceramic Package for Hermeticity

MICRO-T
NPN SILICON AMPLIFIER TRANSISTORS

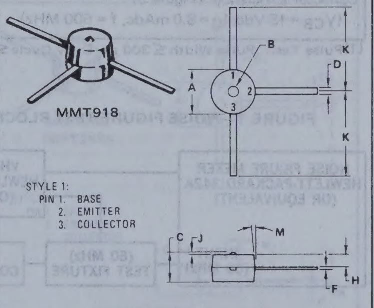


STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	MMCM918	MMT918	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	-55 to +135	°C

THERMAL CHARACTERISTICS

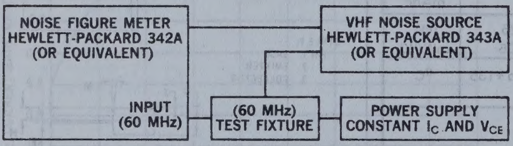
Characteristic	Symbol	MMCM918	MMT918	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	875	490	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.4	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (V_{CE} = 10 Vdc, I_C = 4.0 mAdc, f = 100 MHz)	f_T	600	–	–	MHz
Output Capacitance	C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)		–	–	1.7	
(V_{CB} = 0, I_E = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)		–	–	3.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)	C_{ib}	–	–	2.0	pF
Noise Figure (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	NF	–	–	6.0	dB
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (Figure 2) (V_{CC} = 12 Vdc, I_C = 6.0 mAdc, f = 200 MHz)	G_{pe}	–	23	–	dB
Power Output (Figure 3) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	P_{out}	–	60	–	mW
Collector Efficiency (Figure 3) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	η	–	50	–	%

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – NOISE FIGURE TEST BLOCK DIAGRAM

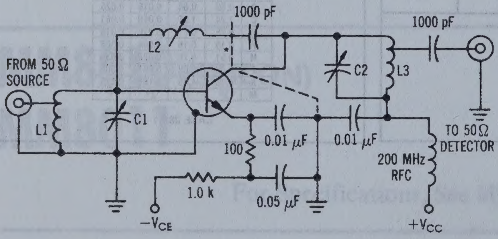


NOISE FIGURE METER
HEWLETT-PACKARD 342A
(OR EQUIVALENT)
INPUT
(60 MHz)
VHF NOISE SOURCE
HEWLETT-PACKARD 343A
(OR EQUIVALENT)
(60 MHz)
TEST FIXTURE
POWER SUPPLY
CONSTANT I_C AND V_{CE}

The test fixture shall consist of a 60 MHz tuned amplifier and suitable biasing circuits. It should be constructed utilizing good very-high-frequency design techniques.

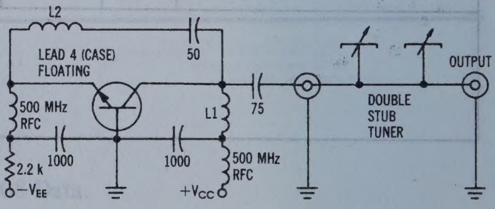
The effective source susceptance should be tuned for each device being tested to obtain minimum noise figure. Note that because the HP 343A has a 50-ohm output resistance, a suitable impedance transformer must be used to obtain an effective source conductance of 2.5 mmho at the transistor with minimum losses.

FIGURE 2 – NEUTRALIZED 200 MHz POWER AMPLIFIER GAIN TEST CIRCUIT



1000 pF
1000 pF
L2
FROM 50 Ω
SOURCE
C2
L3
C1
L1
100
0.01 μF
0.01 μF
TO 50 Ω
DETECTOR
200 MHz
RFC
1.0 k
0.05 μF
$-V_{CE}$
$+V_{CC}$

FIGURE 3 – 500 MHz OSCILLATOR TEST CIRCUIT



L2
LEAD 4 (CASE)
FLOATING
50
OUTPUT
500 MHz
RFC
L1
75
DOUBLE
STUB
TUNER
2.2 k
1000
1000
500 MHz
RFC
$-V_{EE}$
$+V_{CC}$

MMCM930, MMT930 (SILICON)
MMCM2484, MMT2484

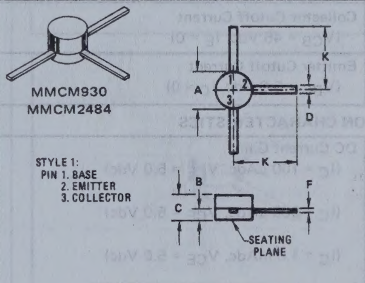
MICRO-T

NPN SILICON AMPLIFIER TRANSISTORS

NPN SILICON ANNULAR TRANSISTORS

. . . designed for low-level, low noise amplifier applications.

- MMT Plastic Micro–T
- MMCM Hermetic Ceramic Micro–T
- Space Saving Micro-Miniature Packages
- High Breakdown Voltages –
  $V_{CEO(sus)}$ = 45 Vdc (Min) @ I_C = 10 mAdc
  (MMT930, MMCM930)
  = 60 Vdc (Min) @ I_C = 10 mAdc
  (MMT2484, MMCM2484)
- High DC Current Gain –
  h_{FE} = 800 (Max) @ I_C = 10 mAdc
- MMT930, MMT2484 – One-Piece, Injection-Molded Unibloc Package for High Reliability
  MMCM930, MMCM2484 – Ceramic Package for Hermeticity

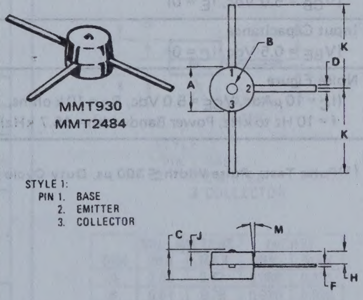


STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	MMCM930 MMT930	MMCM2484 MMT2484	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		MMCM930 MMCM2484	MMT930 MMT2484	
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 1.14	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	MMCM930 MMCM2484	MMT930 MMT2484	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	875	490	$^oC/W$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$			Vdc
	MMCM930,MMT930		45	–	
	MMCM2484,MMT2484		60	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	–	0.01	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMCM930,MMT930		100	–	
	MMCM2484,MMT2484		175	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MMCM930,MMT930		125	–	
	MMCM2484,MMT2484		200	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMCM930,MMT930		150	–	
	MMCM2484,MMT2484		250	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)(1)	All Types		–	800	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.35	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.5	0.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)		f_T	60	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0)		C_{ob}	–	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0)		C_{ib}	–	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to kHz, Power Bandwidth = 15.7 kHz)	MMCM2484,MMT2484	NF	–	3.0	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

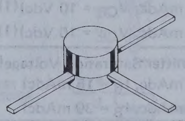
MMCM2222 (SILICON)

NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits and DC to VHF amplifier applications.

- Space Saving Micro-Miniature Packages
- High DC Current Gain Range –
  I_C Specified from 1.0 mA to 300 mA
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- Ceramic Package for Hermeticity

MICRO-T
NPN SILICON SWITCHING TRANSISTORS

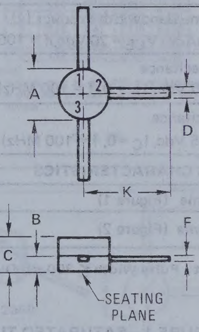


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	875	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)		100	–	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)		30	–	–	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.2	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.9	1.6	
Base-Emitter Saturation Voltage(1)	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.85	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	1.4	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	3.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	–	16	–	ns
Turn-Off Time (Figure 2)	t_{off}	–	160	–	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

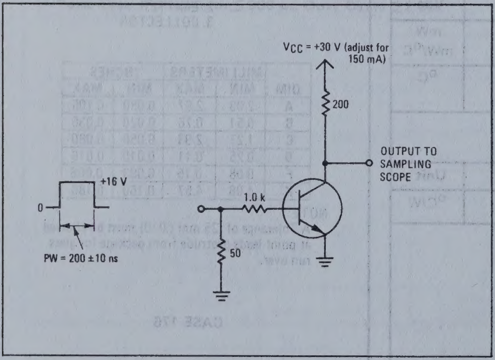
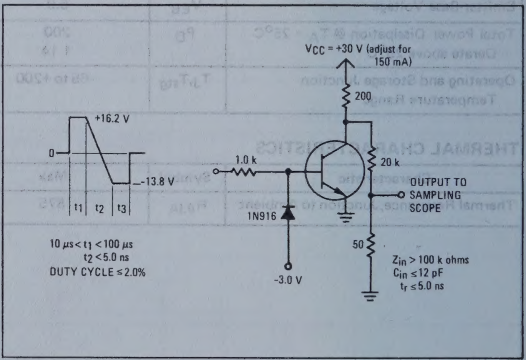

VCC = +30 V (adjust for 150 mA)
200
OUTPUT TO SAMPLING SCOPE
+16 V
0
1.0 k
50
PW = 200 ±10 ns

FIGURE 2 – SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT


VCC = +30 V (adjust for 150 mA)
200
+16.2 V
0
–13.8 V
t1
t2
t3
1.0 k
20 k
OUTPUT TO SAMPLING SCOPE
1N916
50
-3.0 V
10 μs < t1 < 100 μs
t2 < 5.0 ns
DUTY CYCLE ≤ 2.0%
Zin > 100 k ohms
Cin ≤ 12 pF
tr ≤ 5.0 ns

MMCM2369 (SILICON)
MMT2369

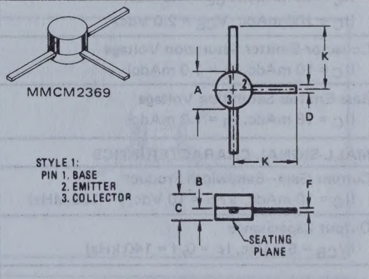
MICRO-T

NPN SILICON SWITCHING TRANSISTORS

NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-speed, low current switching applications where high-density packaging is required.

- Space Saving Micro-Miniature Packages
- Ideal for Thick Film Digital Circuit Applications
- MMT2369 – One-Piece, Injection-Molded Unibloc Package for High Reliability
- MMCM2369 – Ceramic Package for Hermeticity



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

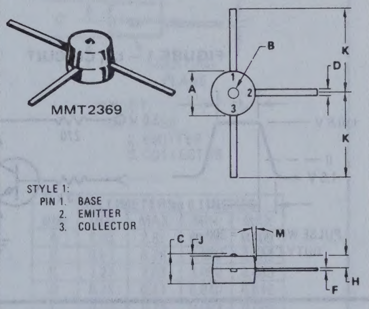
CASE 176

MAXIMUM RATINGS

Rating	Symbol	MMCM2369	MMT2369	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 1.14	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	MMCM2369	MMT2369	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	875	490	$^oC/W$



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3^0	7^0	3^0	7^0

CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20	 120 –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	500	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	4.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	–	18	ns
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	$t_{s(\tau s)}$	–	13	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – t_{on} CIRCUIT

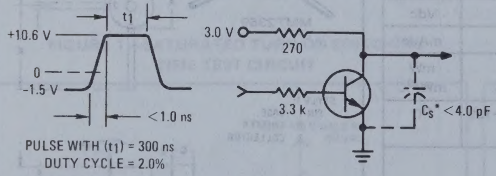
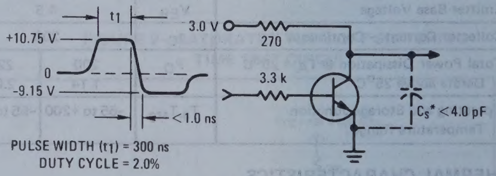

t1
+10.6 V
0
-1.5 V
< 1.0 ns
3.0 V
270
3.3 k
C_s* < 4.0 pF
PULSE WITH (t_1) = 300 ns
DUTY CYCLE = 2.0%

FIGURE 2 – t_{off} CIRCUIT


t1
+10.75 V
0
-9.15 V
< 1.0 ns
3.0 V
270
3.3 k
C_s* < 4.0 pF
PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

*Total shunt capacitance of test jig and connectors.

MMCM2484 (SILICON)

For Specifications, See MMCM930 Data.

MMCM2857 (SILICON) (CERAMIC PACKAGE)

For Specifications, See MMT2857 Data.

MMCM2907 (SILICON)

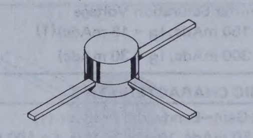
PNP SILICON ANNULAR TRANSISTORS

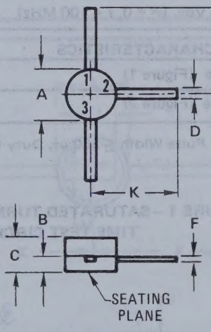
. . . designed for general-purpose switching and amplifier applications, where high-density packaging is required.

- Space Saving Micro-Miniature Packages
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- High Voltage Rating — BV_{CEO} = 40 Vdc (Min)
- DC Current Gain Specified from 1.0 mAdc to 300 mAdc
- MMT2907 — One-Piece, Injection-Molded Unibloc Package for High Reliability

MMCM2907 — Ceramic Package for Hermeticity

MICRO-T
PNP SILICON
SWITCHING AND AMPLIFIER
TRANSISTORS





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	875	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)		100	–	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)		30	–	–	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.2	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	–	1.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)(1)		–	0.85	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	–	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	260	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	4.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	–	20	–	ns
Turn-Off Time (Figure 2)	t_{off}	–	150	–	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

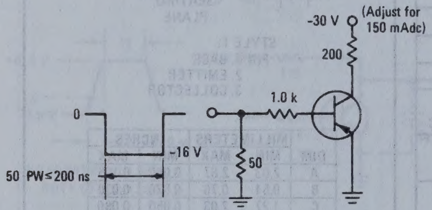
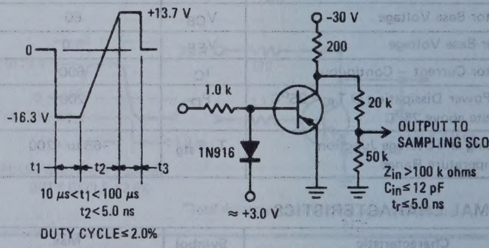

-30 V
(Adjust for 150 mAdc)
200
1.0 k
0
-16 V
50
50 PW≤200 ns

FIGURE 2 – SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT


+13.7 V
0
-16.3 V
t1
t2
t3
10 µs<t1<100 µs
t2<5.0 ns
DUTY CYCLE≤2.0%
-30 V
200
1.0 k
20 k
OUTPUT TO SAMPLING SCOPE
1N916
50 k
Zin >100 k ohms
Cin≤12 pF
tr≤5.0 ns
≈ +3.0 V

MMCM3798, MMCM3799 (SILICON) (CERAMIC PACKAGE)

For Specifications, See MMT3798 Data.

MMCM3903, MMCM3904 (SILICON) (CERAMIC PACKAGE)

For Specifications, See MMT3903 Data.

MMCM3905, MMCM3906 (SILICON) (CERAMIC PACKAGE)

For Specifications, See MMT3905 Data.

MMCM3960A (SILICON) (CERAMIC PACKAGE)

For Specifications, See MMT3960A Data.

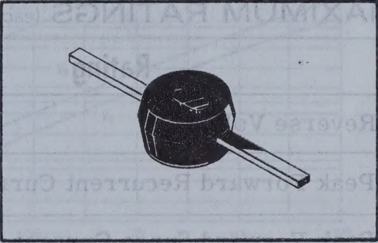
MMD70 (SILICON)

SILICON EPITAXIAL SWITCHING DIODE

. . . designed for general-purpose, high-speed switching applications.

- High Breakdown Voltage – $V_{(BR)}$ = 50 Vdc (Min) @ $I_{(BR)}$ = 100 μAdc
- Space-Saving Micro-Miniature Package
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to MMD6050

MICRO-MINIATURE
SILICON EPITAXIAL
SWITCHING DIODE

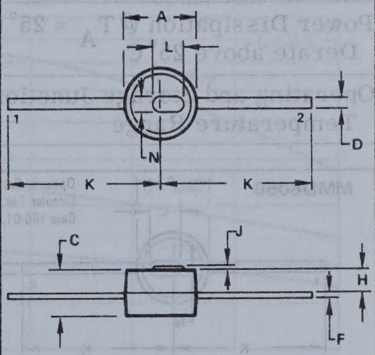


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	50	–	Vdc
Reverse Current (V_R = 30 Vdc)	I_R	–	100	nAdc
Forward Voltage (I_F = 100 mAdc)	V_F	0.75	1.2	Vdc
Capacitance (V_R = 0)	C	–	2.5	pF
Reverse Recovery Time ($I_F = I_R$ = 10 mAdc, V_R = 15 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	15	ns



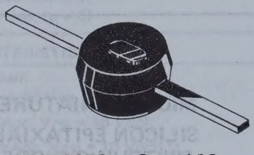
STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
C	1.22	1.47	0.048	0.058
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
L	0.89	1.14	0.035	0.045
N	0.38	0.64	0.015	0.025

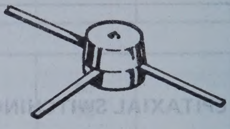
CASE 166-02

MMD6050 (SILICON)
MMD6100
MMD6150
MMD7000

Silicon epitaxial micro-miniature switching diodes – single, series and dual diodes designed for general-purpose, high-speed switching applications.



MMD6050 – Case 166



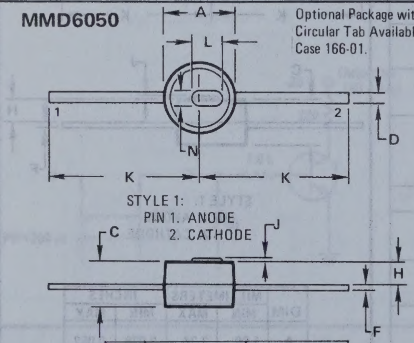
MMD6100 – Case 28 (2)
MMD6150 – Case 28 (3)
MMD7000 – Case 28 (4)

MAXIMUM RATINGS (each diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25° C Derate above 25° C	P_D	225 2.05	mW mW/° C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

MMD6050

Optional Package with Raised Circular Tab Available; Specify Case 166-01.

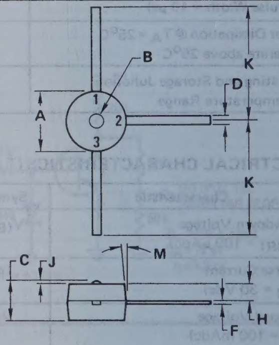


STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
C	1.22	1.47	0.048	0.058
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
L	0.89	1.14	0.035	0.045
N	0.38	0.64	0.015	0.025

CASE 166-02

MMD6100
(Style 2)
MMD6150
(Style 3)
MMD7000
(Style 4)



STYLE 2:
PIN 1. ANODE 2
2. ANODE 1
3. CATHODE

STYLE 3:
PIN 1. CATHODE 2
2. CATHODE 1
3. ANODE

STYLE 4:
PIN 1. CATHODE
2. ANODE
3. COMMON CATHODE ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)} = 100\ \mu Adc$)	$V_{(BR)}$	70	-	-	Vdc
Reverse Current ($V_R = 50$ Vdc)	I_R	-	-	0.1	μAdc
Forward Voltage ($I_F = 1.0$ mAdc) ($I_F = 100$ mAdc)	V_F	 0.55 0.85	 - -	 0.7 1.1	Vdc
Capacitance ($V_R = 0$)	C	-	1.2	2.0	pF
Reverse Recovery Time ($I_F = I_R = 10$ mAdc)	t_{rr}	-	1.5	5.0	ns

FIGURE 1 — FORWARD CHARACTERISTICS

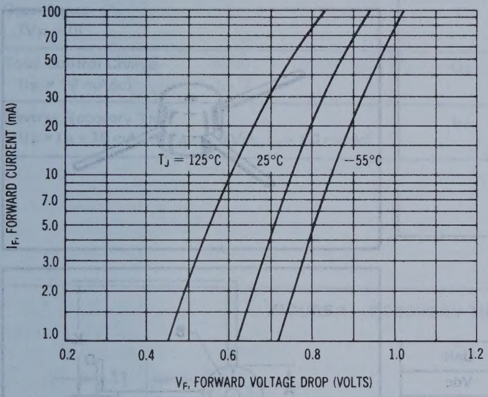


FIGURE 2 — REVERSE LEAKAGE CURRENT versus TEMPERATURE

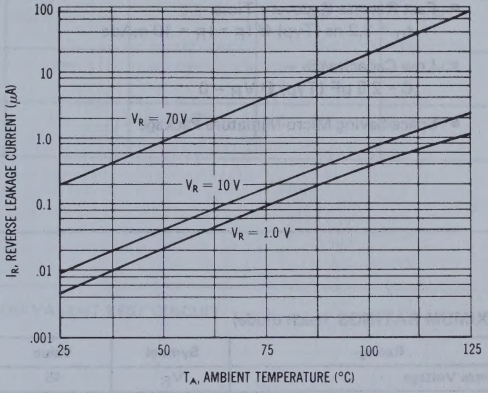


FIGURE 3 — CAPACITANCE

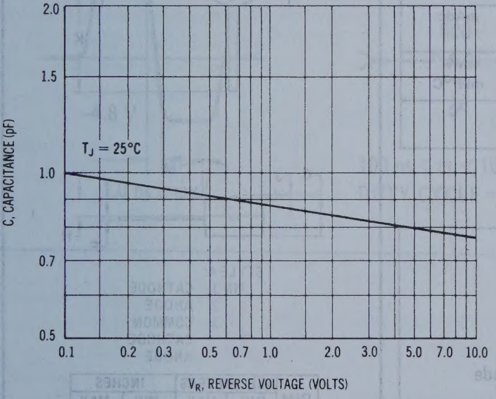


FIGURE 4 — REVERSE RECOVERY TIME

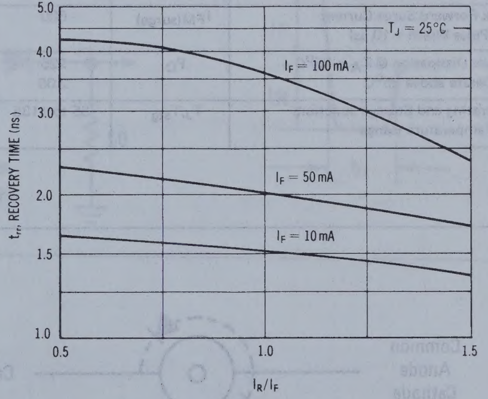
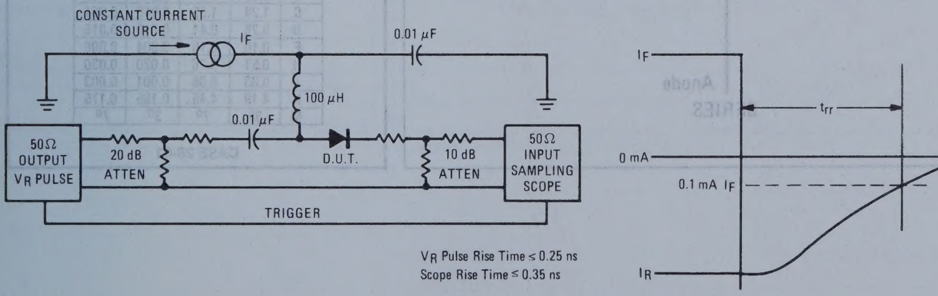


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



CONSTANT CURRENT SOURCE
I_F
0.01 μF
100 μH
0.01 μF
50Ω OUTPUT V_R PULSE
20 dB ATTEN
D.U.T.
10 dB ATTEN
50Ω INPUT SAMPLING SCOPE
TRIGGER
I_F
t_rr
0 mA
0.1 mA I_F
I_R

V_R Pulse Rise Time ≤ 0.25 ns
Scope Rise Time ≤ 0.35 ns

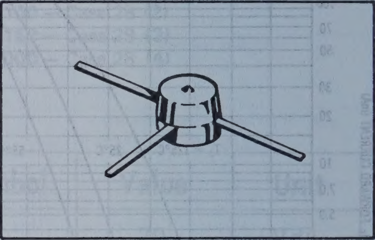
MMD7001 (SILICON)

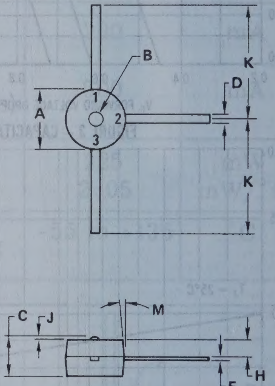
SILICON EPITAXIAL DUAL SWITCHING DIODE

. . . designed for general purpose, high-speed switching applications.

- High Breakdown Voltage —
  $V_{(BR)} = 45$ Vdc (Min) @ $I_{(BR)} = 10\ \mu$Adc
- Fast Reverse Recovery Time —
  $t_{rr} = 3.2$ ns (Typ) @ $I_F = I_R = 10$ mAdc
- Low Capacitance —
  C = 2.5 pF (Typ) @ $V_R = 0$
- Space-Saving Micro-Miniature Package

MICRO-MINIATURE SILICON EPITAXIAL DUAL SWITCHING DIODE





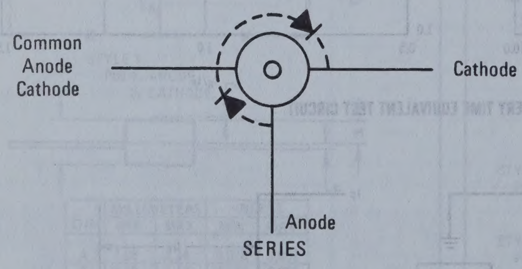
STYLE 4:
PIN 1. CATHODE
2. ANODE
3. COMMON
CATHODE
ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3^0	7^0	3^0	7^0

CASE 28-01

MAXIMUM RATINGS (each diode)

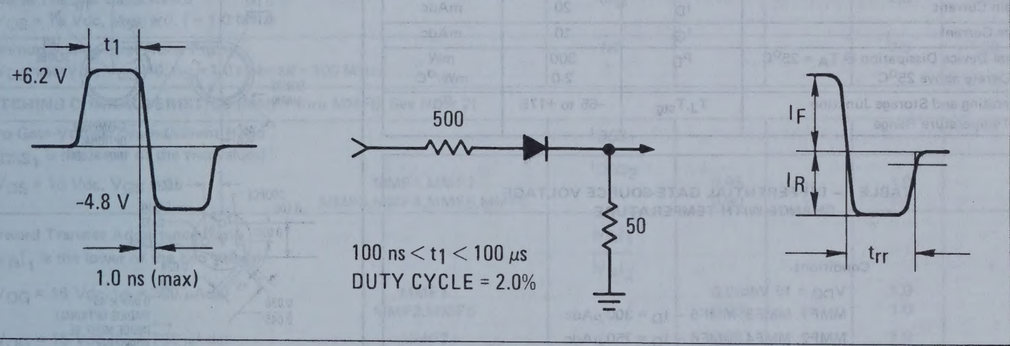
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	45	Vdc
Recurrent Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	600	mAdc
Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC



ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)} = 10\ \mu Adc$)	$V_{(BR)}$	45	–	–	Vdc
Reverse Current ($V_R = 30$ Vdc)	I_R	–	–	0.1	µAdc
Forward Voltage	V_F				Vdc
($I_F = 100$ mAdc)		0.75	–	0.9	
($I_F = 300$ mAdc)		–	–	1.05	
($I_F = 500$ mAdc)		–	–	1.15	
Capacitance ($V_R = 0$)	C	–	2.5	3.5	pF
Total Control Charge ($I_F = 10$ mAdc)	Q_S	–	–	50	pC
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $V_R = 5.0$ Vdc, $i_{rr} = 1.0$ mAdc)	t_{rr}	–	3.2	–	ns

FIGURE 1 – RECOVERY TIME EQUIVALENT TEST CIRCUIT


t1
+6.2 V
-4.8 V
1.0 ns (max)
500
50
100 ns < t1 < 100 µs
DUTY CYCLE = 2.0%
IF
IR
trr

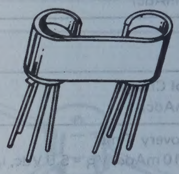
MMF1 thru MMF6 (SILICON)

MATCHED SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

. . . consists of two individual 2N3823 device types which have been carefully matched for critical applications, such as differential amplifier service. Each matched pair is packaged in a metal clip for pair identity and each device is marked with the basic 2N3823 type number and a date code for further identification in the event of removal from the clip.

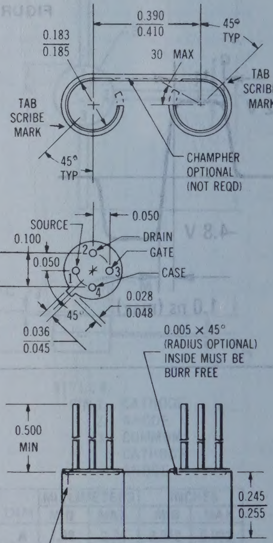
- Guaranteed Temperature Tracking – (0°C to 100°C)
  $\Delta|V_{GS1} - V_{GS2}|/\Delta_T$ = 10 μV/°C – MMF1, MMF2
  25 μV/°C – MMF3, MMF4
  50 μV/°C – MMF5, MMF6
- Excellent Gate-Source Voltage Match –
  $|V_{GS1} - V_{GS2}|$ = 5.0 mVdc (Max)
- Tight I_{DSS} Match –
  ΔI_{DSS} = 5.0% (Max) – MMF1, MMF2
- Low Noise Figure – NF = 2.5 dB (Max) @ 100 MHz (Each Device)

MATCHED JUNCTION FIELD-EFFECT TRANSISTORS TYPE A



MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	20	mAdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C


0.390
0.410
45°
TYP
0.183
0.185
30 MAX
TAB
SCRIBE
MARK
TAB
SCRIBE
MARK
45°
TYP
CHAMPHER
OPTIONAL
(NOT REQD)
SOURCE
0.050
0.100
DRAIN
GATE
0.050
CASE
1
2
3
4
0.028
0.048
45°
0.036
0.045
0.005 × 45°
(RADIUS OPTIONAL)
INSIDE MUST BE
BURR FREE
0.500
MIN
0.245
0.255
SCRIBE MARK INDICATES
LOCATION OF DEVICE TAB

TWO TO-72 CASE 20 (1)
STYLE IN CLIP

TABLE I – DIFFERENTIAL GATE-SOURCE VOLTAGE CHANGE WITH TEMPERATURE

Conditions:

V_{DG} = 15 Vdc
MMF1, MMF3, MMF5 – I_D = 300 μAdc
MMF2, MMF4, MMF6 – I_D = 750 μAdc

Device Type	0°C to +25°C	+25°C to +100°C
MMF1, MMF2	0.250 mVdc	0.750 mVdc
MMF3, MMF4	0.625 mVdc	1.875 mVdc
MMF5, MMF6	1.250 mVdc	3.750 mVdc

ELECTRICAL CHARACTERISTICS (each 2N3823) ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	–	–	Vdc
Gate-Source Voltage ($I_D = 0.4$ mAdc, $V_{DS} = 15$ Vdc)	V_{GS}	1.0	–	7.5	Vdc
Gate-Source Cutoff Voltage ($I_D = 0.5$ nAdc, $V_{DS} = 15$ Vdc)	$V_{GS(off)}$	0.2	–	8.0	Vdc
Gate Reverse Current	I_{GSS}				nAdc
($V_{GS} = 20$ Vdc, $V_{DS} = 0$)		–	–	0.5	
($V_{GS} = 20$ Vdc, $V_{DS} = 0$, $T_A = 150^{\circ}C$)		–	–	500	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current(1) ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	4.0	–	20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance					μmhos
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)(1)	$\lvert y_{fs} \rvert$	3500	–	6500	
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	$Re(y_{fs})$	3200	–		
Input Conductance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	$Re(y_{is})$	–	–	800	μmhos
Output Conductance					μmhos
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)(1)	$\lvert y_{os} \rvert$	–	–	35	
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 200 MHz)	$Re(y_{os})$	–	–	200	
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	–	–	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	–	–	2.0	pF
Common-Source Spot Noise Figure ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $R_S = 1.0$ k ohm, f = 100 MHz)	NF	–	–	2.5	dB
MATCHING CHARACTERISTICS (MMF1 thru MMF6, See Note 2)					
Zero-Gate-Voltage Drain Current Ratio (I_{DSS_1} is the lower of the two values)	$\frac{I_{DSS_1}}{I_{DSS_2}}$				–
($V_{DS} = 15$ Vdc, $V_{GS} = 0$) MMF1,MMF2		0.95	–	1.0	
MMF3,MMF4,MMF5,MMF6		0.90	–	1.0	
Forward Transfer Admittance Ratio ($\lvert y_{fs} \rvert_1$ is the lower of the two values)	$\frac{\lvert y_{fs} \rvert_1}{\lvert y_{fs} \rvert_2}$				–
($V_{DG} = 15$ Vdc, $I_D = 300\ \mu Adc$) MMF1		0.98	–	1.0	
MMF3,MMF5		0.95	–	1.0	
($V_{DG} = 15$ Vdc, $I_D = 750\ \mu Adc$) MMF2		0.98	–	1.0	
MMF4,MMF6		0.95	–	1.0	
Differential Output Conductance	$\lvert \lvert y_{os} \rvert_1 - \lvert y_{os} \rvert_2 \rvert$				μmho
($V_{DG} = 15$ Vdc, $I_D = 750\ \mu Adc$, f = 1.0 kHz) MMF1,MMF3,MMF5		–	–	1.0	
($V_{DG} = 15$ Vdc, $I_D = 300\ \mu Adc$, f = 1.0 kHz) MMF2,MMF4,MMF6		–	–	1.0	
Differential Gate-Source Voltage	$\lvert V_{GS_1} - V_{GS_2} \rvert$				mVdc
($V_{DG} = 15$ Vdc, $I_D = 300\ \mu Adc$) MMF1,MMF3,MMF5		–	–	5.0	
($V_{DG} = 15$ Vdc, $I_D = 750\ \mu Adc$) MMF2,MMF4,MMF6		–	–	5.0	
Differential Gate Reverse Current	$\lvert I_{G_1} - I_{G_2} \rvert$				nAdc
($V_{DG} = 15$ Vdc, $I_D = 300\ \mu Adc$, $T_A = 100^{\circ}C$)		–	1.0	10	
($V_{DG} = 15$ Vdc, $I_D = 750\ \mu Adc$, $T_A = 100^{\circ}C$)		–	1.0	10	
Differential Gate-Source Voltage Change with Temperature		See TABLE I			

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤10%.

(2) Matching characteristics apply only to pairs of devices originally packaged as a matched pair.

MMT70 (SILICON)

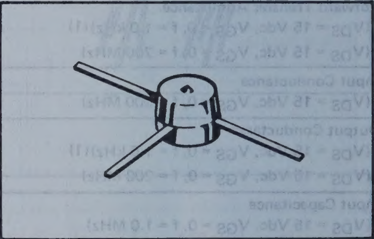
NPN SILICON ANNULAR TRANSISTOR

. . . designed for low-level, low-noise amplifier applications.

- Space Saving Micro-Miniature Package
- One-Piece, Injection Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON
AMPLIFIER
TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

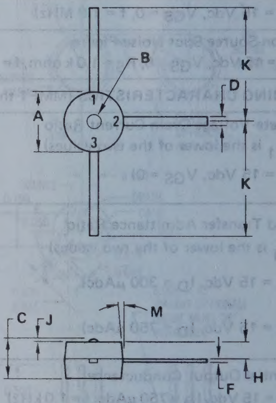
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_B = 0$) (1)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	150	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	–	–	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{ib}	–	–	8.0	pF
Noise Figure ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ k ohms, f = 10 Hz to 15.7 kHz)	NF	–	1.0	–	dB

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3^o	7^o	3^o	7^o

CASE 28-01

MMT71 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for low-level, low-noise amplifier applications.

- Low Noise Figure — NF = 1.5 dB (Typ) @ f = 1.0 kHz
- Low Output Capacitance — C_{ob} = 2.0 pF (Typ) @ V_{CB} = 5.0 Vdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to 2N5086

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous Peak	I_C	50 100	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

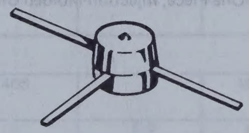
ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

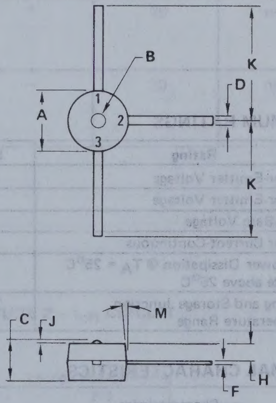
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	150	–	–	–
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	–	10	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kohms, f = 1.0 kHz)	NF	–	1.5	–	dB

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MICRO-MINIATURE

PNP SILICON
AMPLIFIER
TRANSISTOR





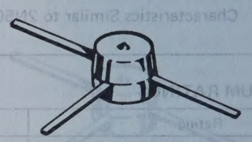
STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MMT72 (SILICON)

MICRO-MINIATURE NPN SILICON SWITCHING TRANSISTOR



NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications where high-density packaging is required.

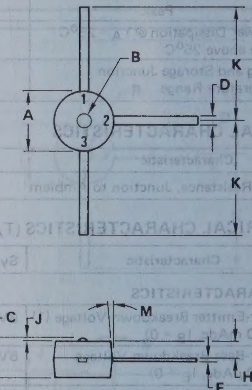
- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Emitter Voltage	V_{CES}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

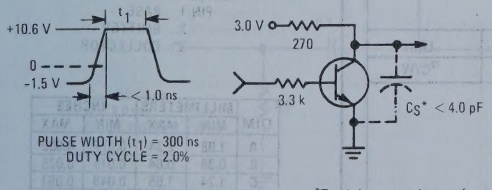
CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	10	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	30	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	20	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	–	30	ns

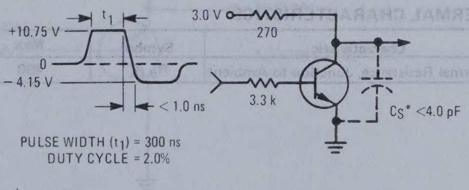
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – t_{on} CIRCUIT



t_1
+10.6 V
0
-1.5 V
< 1.0 ns
3.0 V
270
3.3 k
C_S* < 4.0 pF
PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

FIGURE 2 – t_{off} CIRCUIT



t_1
+10.75 V
0
– 4.15 V
< 1.0 ns
3.0 V
270
3.3 k
C_S* <4.0 pF
PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

*Total shunt capacitance of test jig and connectors.

MMT73 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications where high-density packaging is required.

- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to 2N3546

MAXIMUM RATINGS

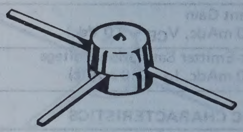
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	8.0	Vdc
Collector-Emitter Voltage	V_{CES}	8.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

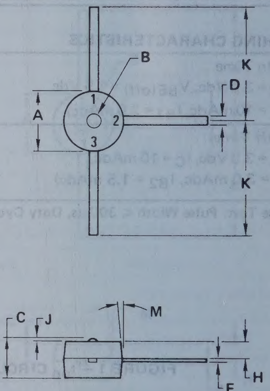
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	$^oC/W$

MICRO-MINIATURE

PNP SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3^0	7^0	3^0	7^0

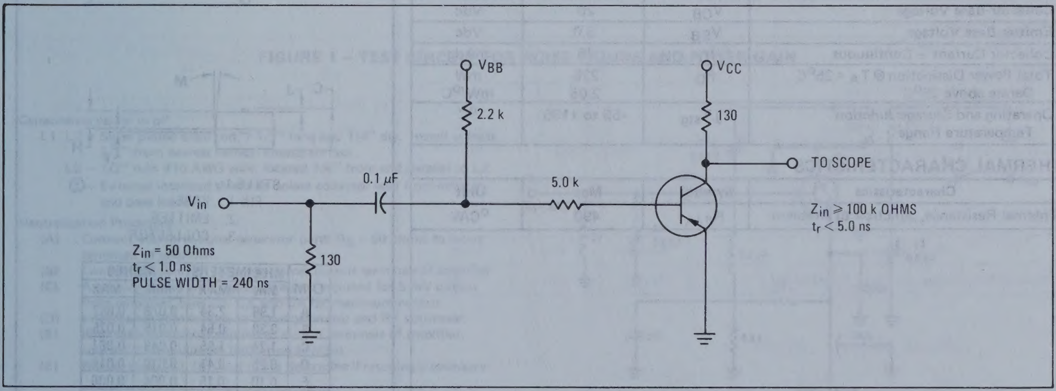
CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	8.0	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 µAdc, V_{BE} = 0)	BV_{CES}	8.0	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 µAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 20	 – –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	–	30	ns
Turn-Off Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	–	30	ns

(1) Pulse Test: Pulse Width ⩽ 300 µs, Duty Cycle ⩽ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



	V_{in} Vdc	V_{BB} Vdc	V_{CC} Vdc	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	Gnd	-1.5	10	1.0	1.0
t_{off}	+10	-8.0	-1.5	10	1.0	1.0

MMT74 (SILICON)

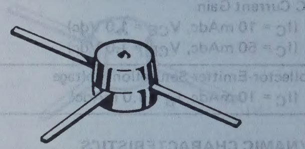
NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-gain, low-noise amplifier, oscillator and mixer applications.

- High Current-Gain—Bandwidth Product — f_T = 1000 MHz (Typ) @ I_C = 4.0 mAdc
- Low Collector — Base Capacitance C_{cb} = 1.0 pF (Typ) @ V_{CB} = 10 Vdc
- One-Piece, Injection Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON RF AMPLIFIER TRANSISTOR

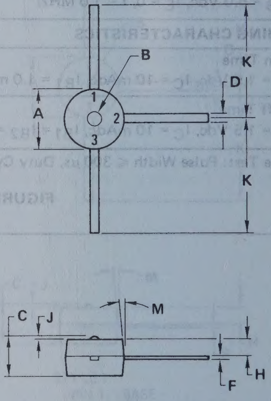


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	40	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	$^oC/W$



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

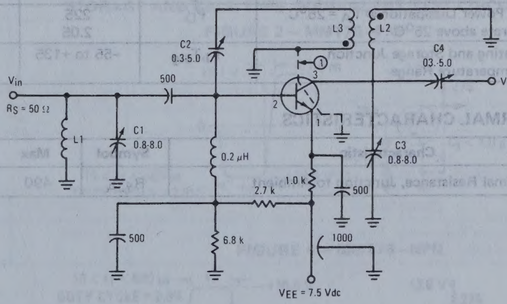
CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	1000	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	1.0	3.0	pF
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 450 MHz)	NF	–	4.0	–	dB
FUNCTIONAL TEST					
Common Emitter Amplifier Power Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	G_{pe}	–	14	–	dB

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 1 — TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver plated brass rod, 1-1/2″ long and 1/4″ dia. Install at least 1/2″ from nearest vertical chassis surface.

L3 – 1/2″ turn #16 AWG wire, located 1/4″ from and parallel to L2.

① – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

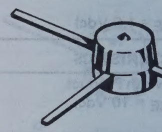
MMT75-PNP (SILICON)
MMT76-NPN

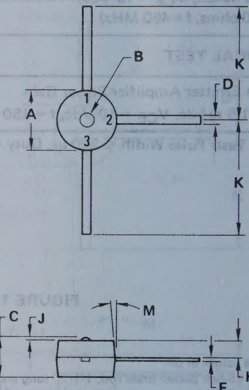
COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose switching and amplifier applications and for complementary circuitry where high-density packaging is required.

- Current Gain Specified in Two Ranges for Design Flexibility
- Low Output Capacitance – C_{ob} = 5.0 pF (Max) @ V_{CB} = 5.0 Vdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to NPN-2N3903, and PNP-2N3905

MICRO-MINIATURE COMPLEMENTARY SILICON SWITCHING AND AMPLIFIER TRANSISTORS





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^{o}C$ Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

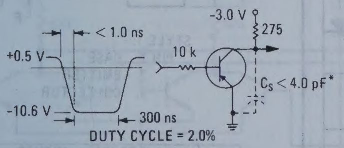
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) Both (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) MMT75 MMT76	h_{FE}	 50 20 30	 – – –	 400 – –	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	–	5.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, MMT75 BW = 10 Hz to 15.7 kHz) MMT76	NF	 – –	 1.0 3.0	 – –	dB
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc) MMT75 MMT76	t_d	– –	25 24	– –	ns
Rise Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc) MMT75 MMT76	t_r	– –	18 13	– –	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MMT75 MMT76	t_s	– –	140 125	– –	ns
Fall Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MMT75 MMT76	t_f	– –	15 11	– –	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — MMT75 —PNP


-3.0 V
275
< 1.0 ns
+0.5 V
10 k
C_s < 4.0 pF*
-10.6 V
300 ns
DUTY CYCLE = 2.0%

STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT

FIGURE 2 — MMT75—PNP

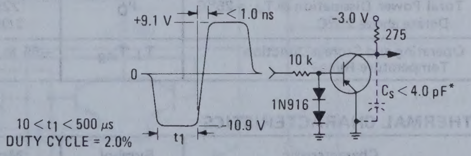

+9.1 V
< 1.0 ns
-3.0 V
275
0
10 k
C_s < 4.0 pF*
1N916
10 < t1 < 500 µs
DUTY CYCLE = 2.0%
-10.9 V
t1

FIGURE 3 — MMT76 —NPN

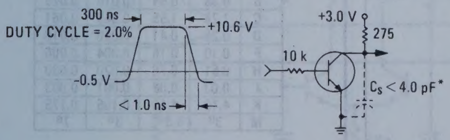
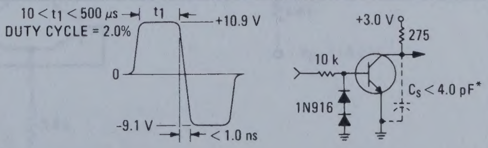

300 ns
DUTY CYCLE = 2.0%
+10.6 V
+3.0 V
275
10 k
-0.5 V
< 1.0 ns
C_s < 4.0 pF*

FIGURE 4 — MMT76 —NPN


10 < t1 < 500 µs
t1
DUTY CYCLE = 2.0%
+10.9 V
+3.0 V
275
0
10 k
C_s < 4.0 pF*
1N916
-9.1 V
< 1.0 ns

*Total shunt capacitance of test jig and connectors

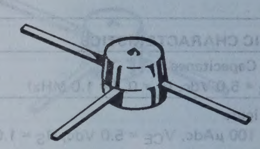
MMT806 (SILICON)

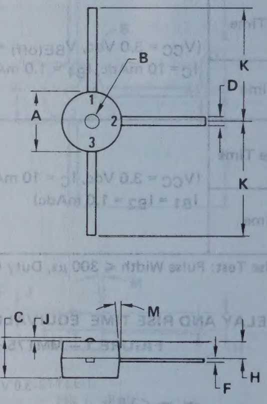
NPN SILICON ANNULAR TRANSISTOR
MICRO POWER SERIES

. . . designed for high-speed, low-power switching circuits.

- DC Current Gain @ Ultra Low Current –
  $h_{FE} = 150$ (Typ) @ $I_C = 1.0\ \mu$Adc
- High Current-Gain – Bandwidth Product –
  $f_T = 2100$ MHz (Typ) @ $I_C = 1.0$ mAdc
- Low Capacitances –
  $C_{ob} = 0.6$ pF (Max) @ $V_{CB} = 1.0$ Vdc
  $C_{ib} = 0.35$ pF (Max) @ $V_{BE} = 1.0$ Vdc
- Space-Saving Micro-Miniature Package
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Complement to PNP Type MMT808

MICRO-MINIATURE
NPN SILICON
SWITCHING
TRANSISTOR





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3^0	7^0	3^0	7^0

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +135	^oC

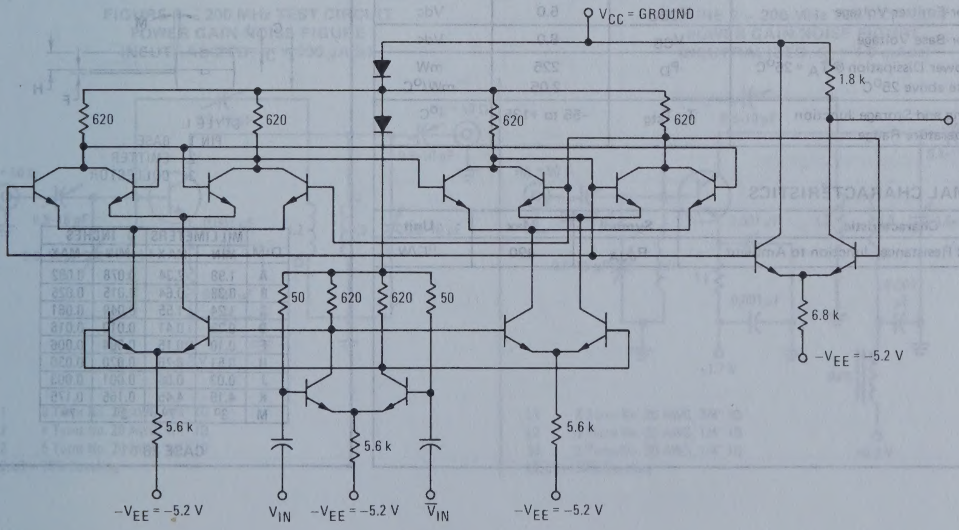
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	5.0	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	8.0	—	—	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, I_B = 0)	I_{CEO}	—	—	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 µAdc, V_{CE} = 1.0 Vdc) (I_C = 100 µAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 20 50	 150 175	 — —	—
Collector-Emitter Saturation Voltage (I_C = 1.0 µAdc, I_B = 0.2 µAdc) (I_C = 100 µAdc, I_B = 10 µAdc)	$V_{CE(sat)}$	 — —	 58 55	 — 100	mVdc
Base-Emitter Saturation Voltage (I_C = 1.0 µAdc, I_B = 0.2 µAdc) (I_C = 100 µAdc, I_B = 10 µAdc)	$V_{BE(sat)}$	 — —	 0.58 0.69	 0.70 0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 1.0 µAdc, V_{CE} = 1.0 Vdc, f = 200 MHz) (I_C = 10 µAdc, V_{CE} = 1.0 Vdc, f = 200 MHz) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)	f_T	 — — 1200	 20 120 2100	 — — —	MHz
Output Capacitance (V_{CB} = 1.0 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	—	0.33	0.6	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	—	0.2	0.35	pF

FIGURE 1 — 250 MHz TYPICAL OPERATING FREQUENCY CIRCUIT
(At Total P_D Unloaded of 10 mW)



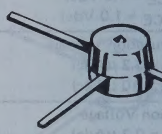
MMT807 (SILICON)

NPN SILICON ANNULAR TRANSISTOR
MICRO POWER SERIES

. . . designed for high-frequency, low-power amplifier applications.

- DC Current Gain @ Ultra Low Current – h_{FE} = 125 (Typ) @ I_C = 10 μAdc
- High Current-Gain–Bandwidth Product – f_T = 2100 MHz (Typ) @ I_C = 1.0 mAdc
- Low Capacitances –
  C_{ob} = 0.55 pF (Max) @ V_{CB} = 0.5 Vdc
  C_{ib} = 0.45 pF (Max) @ V_{BE} = 0
- Typical Power Gain = 18 dB @ I_C = 100 μAdc
- Typical Noise Figure = 2.0 dB @ I_C = 100 μAdc
- Space Saving Micro-Miniature Package
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Complement to PNP Type MMT809

MICRO-MINIATURE
NPN SILICON
AMPLIFIER
TRANSISTOR

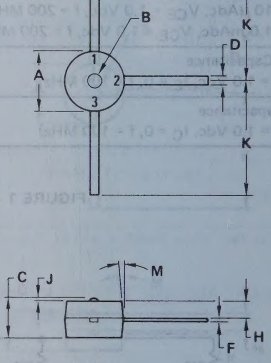


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

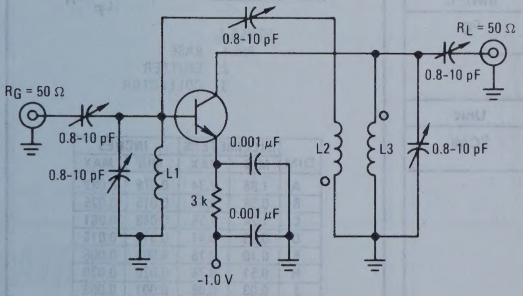
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	5.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	8.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 1.0 Vdc)		20	125	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		25	150	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				mVdc
(I_C = 10 μAdc, I_B = 1.0 μAdc)		–	71	100	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	56	125	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 10 μAdc, I_B = 1.0 μAdc)		–	0.62	0.70	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	0.77	0.85	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)	f_T	1200	2100	–	MHz
Output Capacitance (V_{CB} = 0.5 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	0.34	0.55	pF
Input Capacitance (V_{BE} = 0, I_C = 0, f = 100 MHz)	C_{ib}	–	0.27	0.45	pF
Noise Figure	NF				dB
(I_C = 100 μAdc, V_{CE} = 0.7 Vdc) (Figure 1)		–	2.0	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (Figure 2)		–	2.5	–	
Power Gain	G_{pe}				dB
(I_C = 100 μAdc, V_{CE} = 0.7 Vdc, f = 200 MHz) (Figure 1)		–	18	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz) (Figure 2)		–	23	–	

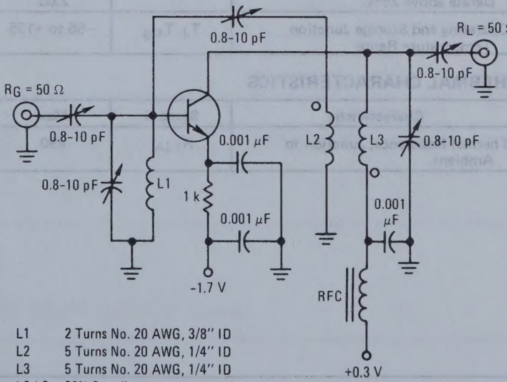
FIGURE 1 – 200 MHz TEST CIRCUIT
POWER GAIN-NOISE FIGURE
(NEUTRALIZED, I_C = 100 μAdc)



0.8-10 pF
R_L = 50 Ω
0.8-10 pF
R_G = 50 Ω
0.8-10 pF
0.001 μF
L2
L3
0.8-10 pF
0.8-10 pF
L1
3 k
0.001 μF
-1.0 V

L1 3 Turns No. 20 AWG, 1/4″ ID
L2 4 Turns No. 20 AWG, 1/4″ ID
L3 5 Turns No. 20 AWG, 1/4″ ID
L2,L3 ≈ 30% Coupling

FIGURE 2 – 200 MHz TEST CIRCUIT
POWER GAIN-NOISE FIGURE
(NEUTRALIZED, I_C = 1.0 mAdc)



0.8-10 pF
R_L = 50 Ω
0.8-10 pF
R_G = 50 Ω
0.8-10 pF
0.001 μF
L2
L3
0.8-10 pF
0.8-10 pF
L1
1 k
0.001 μF
0.001 μF
-1.7 V
RFC
+0.3 V

L1 2 Turns No. 20 AWG, 3/8″ ID
L2 5 Turns No. 20 AWG, 1/4″ ID
L3 5 Turns No. 20 AWG, 1/4″ ID
L2,L3 ≈ 30% Coupling

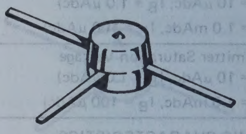
MMT808 (SILICON)

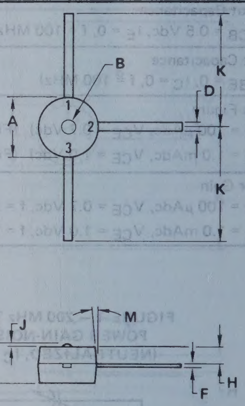
PNP SILICON ANNULAR TRANSISTOR
MICRO POWER SERIES

. . . designed for high-speed, low-power switching circuits.

- DC Current Gain @ Ultra Low Current –
  h_{FE} = 65 (Typ) @ I_C = 1.0 μAdc
- High Current-Gain – Bandwidth Product –
  f_T = 2500 MHz (Typ) @ I_C = 1.0 mAdc
- Low Capacitances –
  C_{ob} = 0.8 pF (Max) @ V_{CB} = 1.0 Vdc
  C_{ib} = 0.3 pF (Max) @ V_{BE} = 1.0 Vdc
- Space Saving Micro-Miniature Package
- One-Piece, Injection Molded Unibloc Package for High Reliability
- Complement to NPN Type MMT806

MICRO-MINIATURE
PNP SILICON
TRANSISTOR





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	5.0	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	8.0	–	–	Vdc
Collector Cutoff Current ($V_{CE} = 4.0$ Vdc, $I_B = 0$)	I_{CEO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
($I_C = 1.0\ \mu$Adc, $V_{CE} = 1.0$ Vdc)		20	65	–	
($I_C = 100\ \mu$Adc, $V_{CE} = 1.0$ Vdc)		50	80	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				mVdc
($I_C = 1.0\ \mu$Adc, $I_B = 0.2\ \mu$Adc)		–	94	–	
($I_C = 100\ \mu$Adc, $I_B = 10\ \mu$Adc)		–	74	100	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
($I_C = 1.0\ \mu$Adc, $I_B = 0.2\ \mu$Adc)		–	0.58	0.7	
($I_C = 100\ \mu$Adc, $I_B = 10\ \mu$Adc)		–	0.69	0.8	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product	f_T				MHz
($I_C = 1.0\ \mu$Adc, $V_{CE} = 1.0$ Vdc, f = 200 MHz)		–	20	–	
($I_C = 10\ \mu$Adc, $V_{CE} = 1.0$ Vdc, f = 200 MHz)		–	100	–	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc, f = 200 MHz)		1200	2500	–	
Output Capacitance ($V_{CB} = 1.0$ Vdc, $I_E = 0$, f = 100 MHz)	C_{ob}	–	0.42	0.8	pF
Input Capacitance ($V_{BE} = 1.0$ Vdc, $I_C = 0$, f = 100 MHz)	C_{ib}	–	0.2	0.3	pF

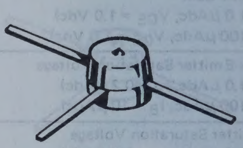
MMT809 (SILICON)

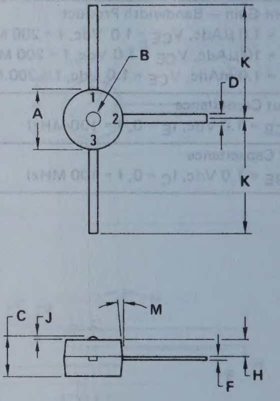
PNP SILICON ANNULAR TRANSISTOR
MICRO POWER SERIES

. . . designed for high-frequency, low-power amplifier applications.

- DC Current Gain @ Ultra Low Current –
  h_{FE} = 70 (Typ) @ I_C = 10 μAdc
- Low Capacitances –
  C_{ob} = 0.8 pF (Max)
  C_{ib} = 0.5 pF (Max)
- Typical Power Gain = 17 dB @ I_C = 100 μAdc
- Typical Noise Figure = 2.6 dB @ I_C = 100 μAdc
- High Current-Gain–Bandwidth Product –
  f_T = 2500 MHz (Typ) @ I_C = 1.0 mAdc
- Space Saving Micro-Miniature Package
- One-Piece, Injection Molded Unibloc Package for High Reliability
- Complement to NPN Type MMT807

MICRO-MINIATURE
PNP SILICON
AMPLIFIER
TRANSISTOR





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	8.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

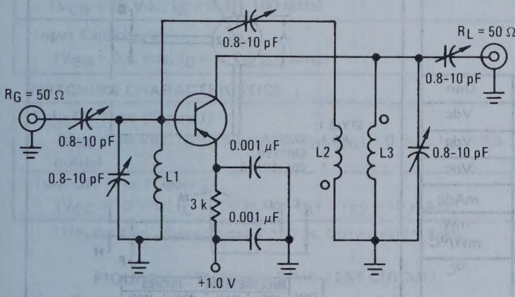
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

MMT809 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

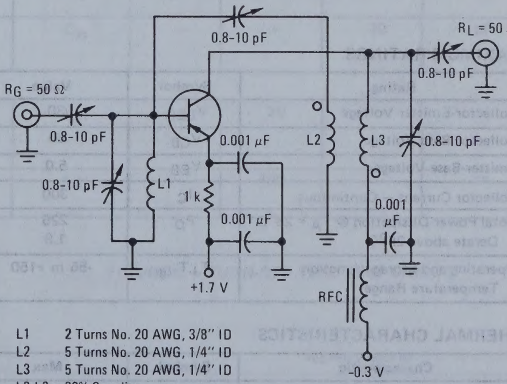
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	5.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	8.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 10 μAdc, V_{CE} = 1.0 Vdc)		20	70	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		25	75	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				mVdc
(I_C = 10 μAdc, I_B = 1.0 μAdc)		–	100	130	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	68	125	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 10 μAdc, I_B = 1.0 μAdc)		–	0.64	0.70	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	0.78	0.85	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, f = 200 MHz)	f_T	1200	2500	–	MHz
Output Capacitance (V_{CB} = 0.5 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	0.47	0.8	pF
Input Capacitance (V_{BE} = 0, I_C = 0, f = 100 MHz)	C_{ib}	–	0.34	0.5	pF
Noise Figure	NF				dB
(I_C = 100 μAdc, V_{CE} = 0.7 Vdc) (Figure 1)		–	2.6	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (Figure 2)		–	3.0	–	
Power Gain	G_{pe}				dB
(I_C = 100 μAdc, V_{CE} = 0.7 Vdc) (Figure 1)		–	17	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (Figure 2)		–	23	–	

FIGURE 1 – 200 MHz TEST CIRCUIT
POWER GAIN – NOISE FIGURE
(NEUTRALIZED, I_C = 100 μAdc)


0.8-10 pF
R_L = 50 Ω
0.8-10 pF
R_G = 50 Ω
0.8-10 pF
0.8-10 pF
L1
0.001 μF
L2
L3
0.8-10 pF
3 k
0.001 μF
+1.0 V

L1 3 Turns No. 20 AWG, 1/4″ ID
L2 4 Turns No. 20 AWG, 1/4″ ID
L3 5 Turns No. 20 AWG, 1/4″ ID
L2,L3 ≈ 30% Coupling

FIGURE 2 – 200 MHz TEST CIRCUIT
POWER GAIN – NOISE FIGURE
(NEUTRALIZED, I_C = 1.0 mAdc)


0.8-10 pF
R_L = 50 Ω
0.8-10 pF
R_G = 50 Ω
0.8-10 pF
0.001 μF
L2
L3
0.8-10 pF
0.8-10 pF
L1
1 k
0.001 μF
0.001 μF
+1.7 V
RFC
-0.3 V

L1 2 Turns No. 20 AWG, 3/8″ ID
L2 5 Turns No. 20 AWG, 1/4″ ID
L3 5 Turns No. 20 AWG, 1/4″ ID
L2,L3 ≈ 30% Coupling

MMT918 (SILICON)

For Specifications, See MMCM918 Data.

MMT930 (SILICON)

For Specifications, See MMCM930 Data.

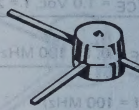
MMT2222 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed switching circuits and DC to VHF amplifier applications.

- Space Saving Micro-Miniature Package
- High DC Current Gain Range – I_C Specified from 1.0 mA to 300 mA
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)} = 0.4$ Vdc (Max) @ $I_C = 150$ mAdc

MICRO-T
NPN SILICON SWITCHING TRANSISTOR

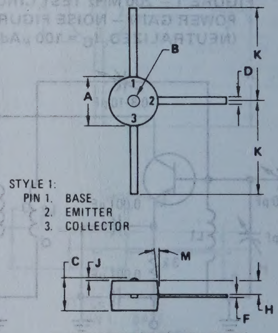


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	300	mAdc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	225 1.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	555	°C/W



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

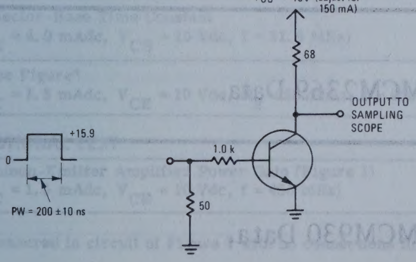
CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	0.05	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		100	–	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		30	–	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.12	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.22	1.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.85	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.96	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	340	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	3.5	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (V_{CC} = 10 Vdc, I_C = 150 mAdc, $V_{BE(off)}$ = 0 Vdc, I_{B1} = 15 mAdc)	t_{on}	–	20	–	ns
Turn-Off Time (Figure 2) (V_{CC} = 10 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	–	180	–	ns

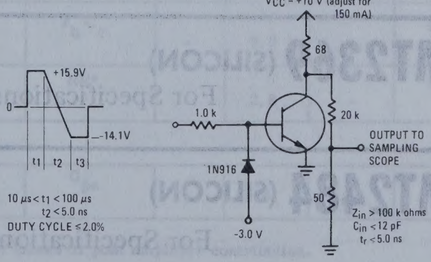
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON TIME TEST CIRCUIT



VCC = +10V (adjust for 150 mA)
68
OUTPUT TO SAMPLING SCOPE
+15.9
0
PW = 200 ±10 ns
1.0 k
50

FIGURE 2 – TURN-OFF TIME TEST CIRCUIT



+15.9V
0
-14.1V
t1
t2
t3
10 μs < t1 < 100 μs
t2 < 5.0 ns
DUTY CYCLE ≤ 2.0%
VCC = +10 V (adjust for 150 mA)
68
1.0 k
20 k
1N916
-3.0 V
OUTPUT TO SAMPLING SCOPE
50
Zin > 100 k ohms
Cin < 12 pF
tr < 5.0 ns

Rise time (t_r) of applied pulse shall be 2.0 ns max; Duty Cycle ≤ 2.0%.

FIGURE 3 – DC CURRENT GAIN

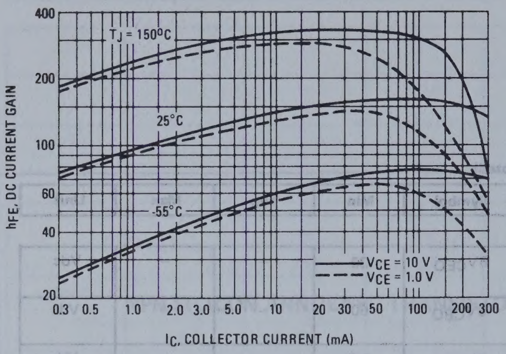


FIGURE 4 – "ON" VOLTAGES

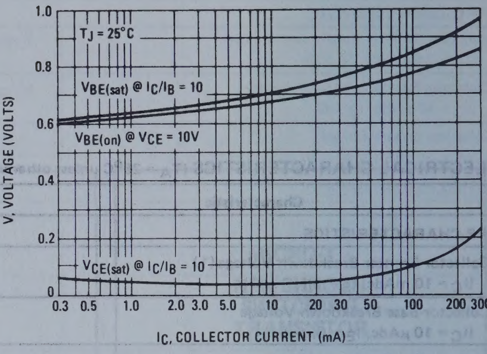


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

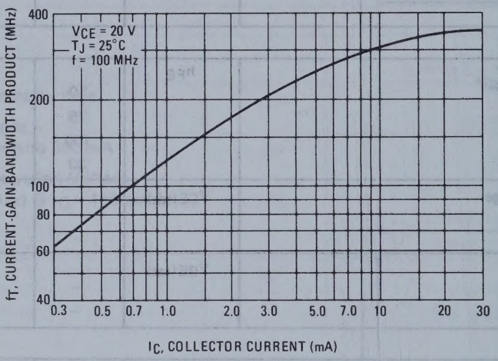


FIGURE 6 – TURN-ON-TIME

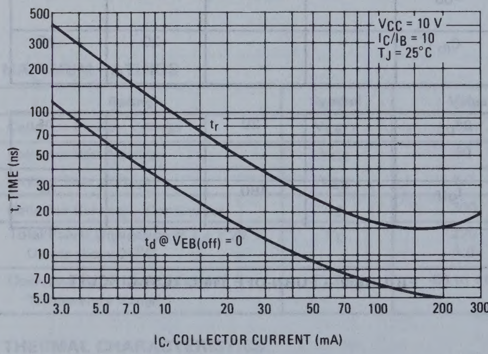
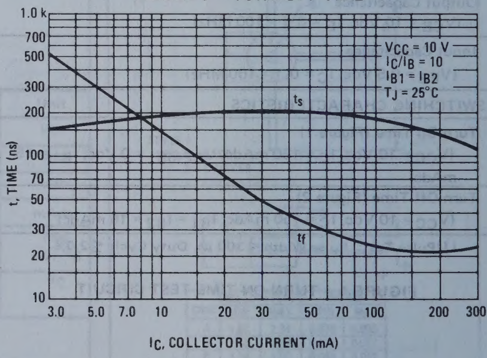


FIGURE 7 – TURN-OFF-TIME



MMT2369 (SILICON)

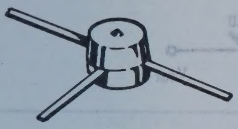
For Specifications, See MMCM2369 Data.

MMT2484 (SILICON)

For Specifications, See MMCM930 Data.

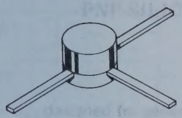
MMT2857 (SILICON)
MMCM2857 (CERAMIC PACKAGE)

MMT2857



CASE 28(1)

MMCM2857



CASE 176

NPN silicon annular micro-miniature transistor designed for high-gain, low-noise amplifier, oscillator and mixer applications.

MAXIMUM RATINGS

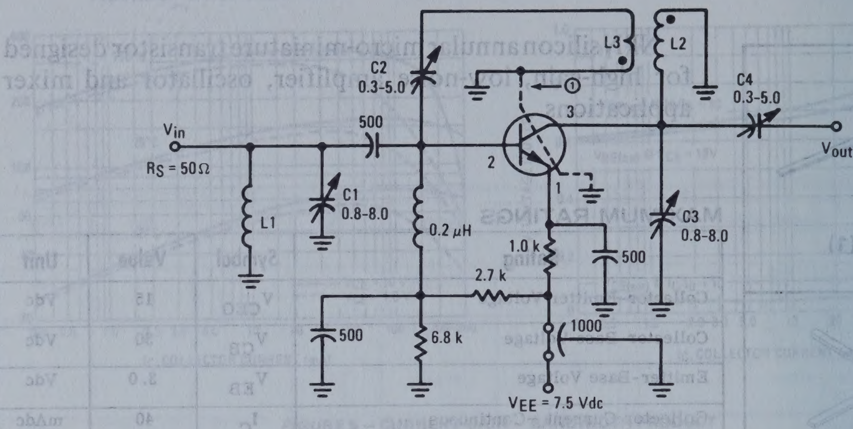
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current –Continuous	I_C	40	mAdc
Total Power Dissipation @T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C and case grounded unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz	f_T	1,000	1,300	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz) (Emitter and Case Guarded)	C_{cb}	-	0.5	1.0	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.9 MHz)	$r_b'C_c$	-	8.0	-	ps
Noise Figure* (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 450 MHz)	NF*	-	3.8	-	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	G_{pe}	-	18	-	dB

*Measured in circuit of Figure 1 with no connections for input circuit losses or post amplifier contribution.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2″ long and 1/4″ dia. Install at least 1/2″ from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4″ from and parallel to L2.

① – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

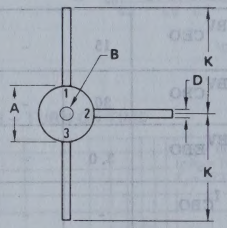
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

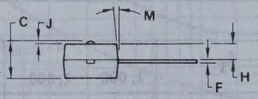
(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

MMT2857



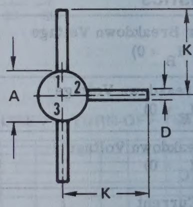
STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR



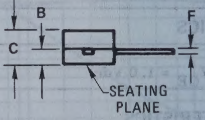
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MMCM2857



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176

MMT2907 (SILICON)

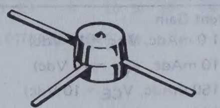
MICRO-T

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTOR

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose switching and amplifier applications, where high-density packaging is required.

- Space Saving Micro-Miniature Package
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- DC Current Gain Specified from 1.0 mAdc to 300 mAdc

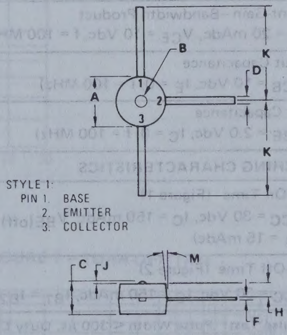


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	300	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	555	C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 300 mAdc, V_{CE} = 10 Vdc)	h_{FE}	50 75 100 30	– – – –	– – 300 –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{CE(sat)}$	– –	0.15 0.24	0.4 1.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{BE(sat)}$	– –	0.87 0.94	1.3 2.6	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	340	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	4.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (V_{CC} = 30 Vdc, I_C = 150 mAdc, $V_{BE(off)}$ = 0, I_{B1} = 15 mAdc)	t_{on}	–	20	–	ns
Turn-Off Time (Figure 2) (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	–	120	–	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON TIME TEST CIRCUIT

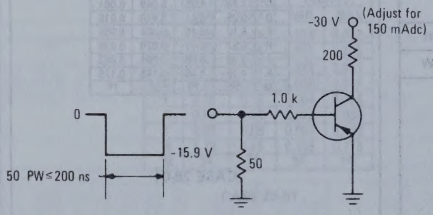

-30 V
(Adjust for
150 mAdc)
200
0
1.0 k
-15.9 V
50
50 PW≤200 ns

FIGURE 2 – TURN-OFF TIME TEST CIRCUIT

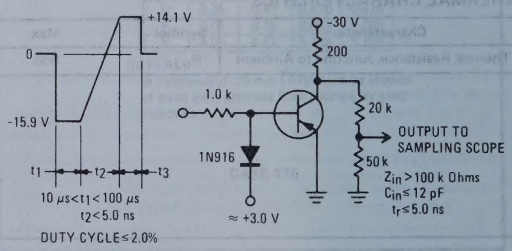

+14.1 V
-30 V
0
200
1.0 k
-15.9 V
20 k
OUTPUT TO
SAMPLING SCOPE
1N916
50 k
t1
t2
t3
Z_{in} > 100 k Ohms
C_{in} ≤ 12 pF
t_r ≤ 5.0 ns
10 μs<t1<100 μs
t2<5.0 ns
DUTY CYCLE≤2.0%
≈ +3.0 V

FIGURE 3 – DC CURRENT GAIN

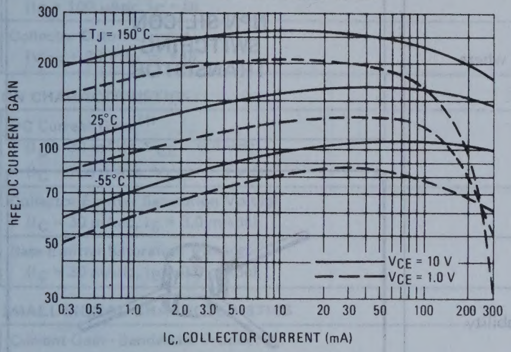


FIGURE 4 – "ON" VOLTAGES

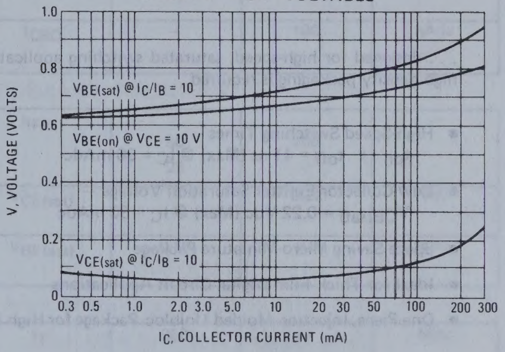


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

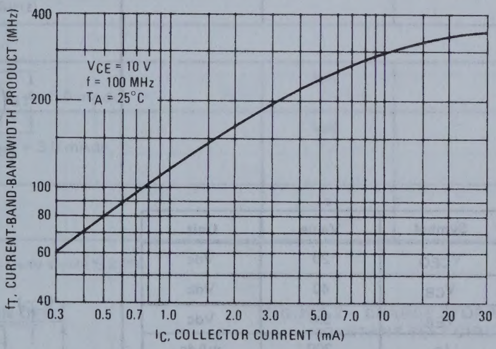


FIGURE 6 – TURN-ON-TIME

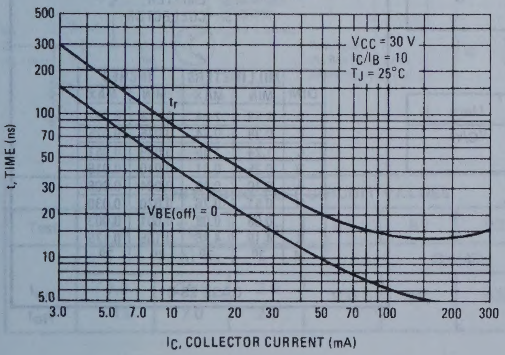
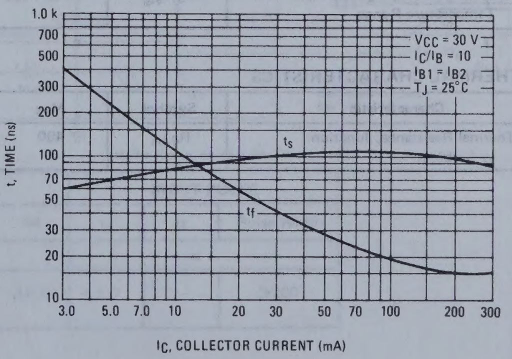


FIGURE 7 – TURN-OFF-TIME



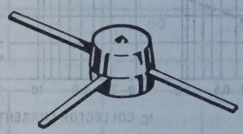
MMT3014 (SILICON)

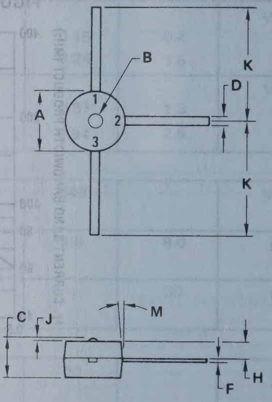
NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, saturated switching applications where high-density packaging is required.

- High-Speed Switching Times – $t_{on} + t_{off}$ = 41 ns (Max) @ I_C = 30 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.22 Vdc (Max) @ I_C = 30 mAdc
- Space Saving Micro-Miniature Package
- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE
NPN SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 50 25	 200 –	–
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$		0.22	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	0.70	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (1) (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	–	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	8.0	pF
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	16	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 3.0 mAdc)	t_{off}	–	25	ns
Charge Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_s	–	18	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

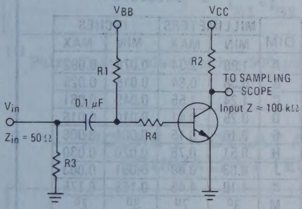
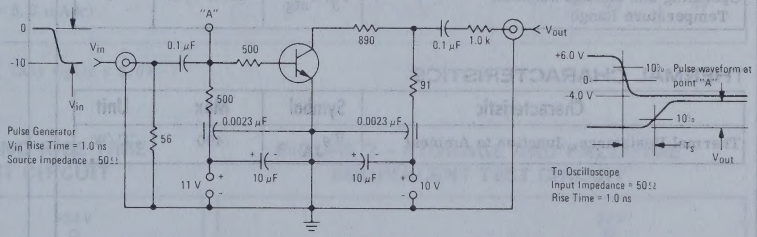

V_{BB}
V_{CC}
R1
R2
TO SAMPLING SCOPE
Input Z ≈ 100 kΩ
V_{in}
0.1 μF
Z_{in} = 50 Ω
R4
R3

FIGURE 2 – CHARGE STORAGE TIME CONSTANT TEST CIRCUIT


0
-10
V_{in}
V_{in}
Pulse Generator
V_{in} Rise Time = 1.0 ns
Source Impedance = 50 Ω
"A"
0.1 μF
500
500
56
0.0023 μF
0.0023 μF
10 μF
10 μF
11 V
10 V
890
91
0.1 μF
1.0 k
V_{out}
+6.0 V
0
-4.0 V
10%
10%
Pulse waveform at point "A"
T_s
V_{out}
To Oscilloscope
Input Impedance = 50 Ω
Rise Time = 1.0 ns

V_{in} Rise Time less than 1.0 ns, PW = 300 ns, Duty Cycle = 2.0%

SWITCHING TEST CIRCUIT VALUES								INPUT PULSE		
Test	V_{in}	V_{BB}	V_{CC}	R1	R2	R3	R4	t_r	t_f	Pulse Width
	VOLTS			OHMS				ns		
t_{on}	7.0	GND	2.0	100	62	100	2.0 k	<1.0	–	>200
t_{off}	-13	7.0	2.0							

MMT3546 (SILICON)

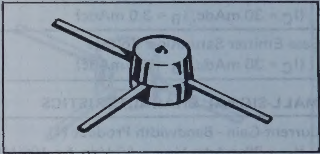
PNP SILICON ANNULAR TRANSISTOR

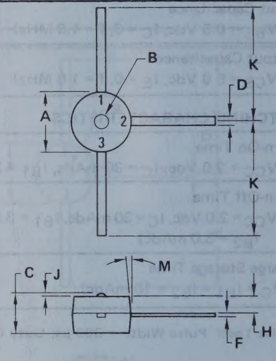
. . . designed for high-speed, low-level switching applications, where high-density packaging is required.

- Space Saving Micro-Miniature Package
- Ideal for Thick Film Digital Circuit Applications
- Total Switching Time = 60 ns @ I_C = 50 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE

PNP SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current - Continuous	I_C	250	mAdc
Total Power Dissipation @T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

MMT3546 (continued)

ELECTRICAL CHARACTERISTICS (T$_A$ = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 15	 - -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 - -	 0.15 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 0.7 -	 0.9 1.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 3.0 Vdc, V_{BE} = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc)	t_d	-	10	ns
Rise Time (V_{CC} = 3.0 Vdc, V_{BE} = 2.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc)	t_r	-	15	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_s	-	20	ns
Fall Time (V_{CC} = 3.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	t_f	-	15	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

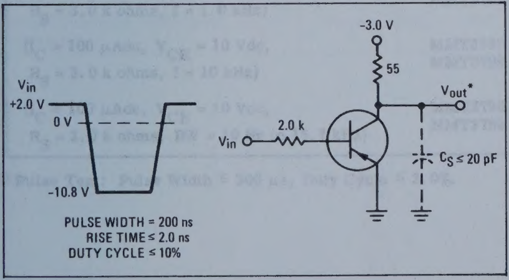
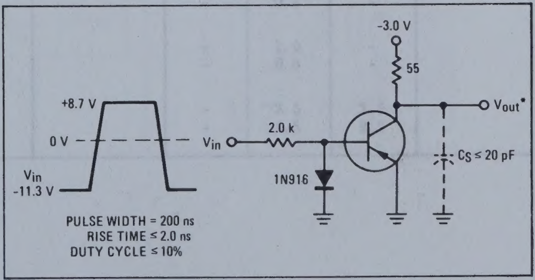
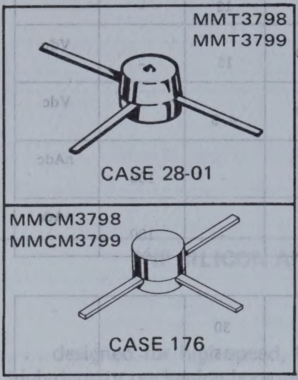

Vin
+2.0 V
0 V
-10.8 V
-3.0 V
55
Vout*
2.0 k
Vin
CS ≤ 20 pF
PULSE WIDTH = 200 ns
RISE TIME ≤ 2.0 ns
DUTY CYCLE ≤ 10%

FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT


-3.0 V
55
+8.7 V
0 V
Vin
2.0 k
Vout*
1N916
CS ≤ 20 pF
Vin
-11.3 V
PULSE WIDTH = 200 ns
RISE TIME ≤ 2.0 ns
DUTY CYCLE ≤ 10%

*OSCILLOSCOPE RISE TIME ≤ 1.0 ns

MMT3798, MMT3799 (SILICON)
MMCM3798, MMCM3799 (CERAMIC PACKAGE)



PNP silicon annular micro-miniature transistors designed for low-level, low-noise amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

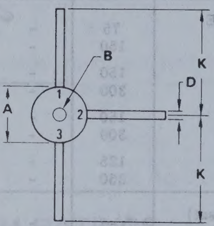
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

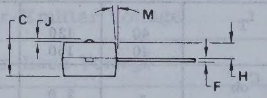
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)		BV_{CBO}	60			Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				-
(I_C = 10 µAdc, V_{CE} = 5.0 Vdc)	MMT3798 MMT3799		75 150	- -	- -	
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc)	MMT3798 MMT3799		150 300	- -	450 900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMT3798 MMT3799		150 300	- -	- -	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMT3798 MMT3799		125 250	- -	- -	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 µAdc)		$V_{CE(sat)}$	-	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 µAdc)		$V_{BE(sat)}$	-	-	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 µAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	MMT3798 MMT3799	f_T	40 40	120 150	- -	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	2.0	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798 MMT3799	h_{ie}	- -	8.0 16	- -	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798 MMT3799	h_{re}	- -	2.0 4.0	- -	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798 MMT3799	h_{fe}	- -	275 475	- -	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798 MMT3799	h_{oe}	- -	18 30	- -	µmhos
Noise Figure (I_C = 100 µAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 100 Hz)	MMT3798 MMT3799	NF	- -	4.0 2.5	- -	dB
(I_C = 100 µAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	MMT3798 MMT3799		- -	1.5 0.8	- -	
(I_C = 100 µAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 kHz)	MMT3798 MMT3799		- -	1.0 0.8	- -	
(I_C = 100 µAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, BW = 10 Hz to 15.7 kHz)	MMT3798 MMT3799		- -	2.5 1.5	3.5 2.5	

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

MMT3798
MMT3799



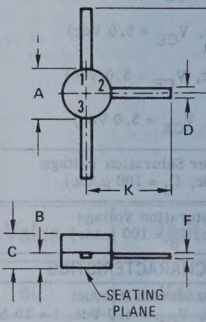
STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MMCM3798
MMCM3799



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176

MMT3823 (SILICON)

MICRO-T
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

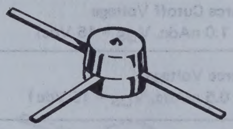
Depletion Mode (Type A) Field-Effect Transistor designed for RF amplifier and mixer applications where high density packaging is required.

- Low Cross-Modulation and Intermodulation Distortion
- Drain and Source Interchangeable
- Low 100-MHz Noise Figure – 2.0 dB (Typ)
- Low Transfer and Input Capacitances
  C_{rss} = 1.0 pF (Typ); C_{iss} = 4.0 pF (Typ)
- Space Saving Micro-Miniature Package – Ideal for Thick Film Circuit Applications

MICRO-MINIATURE JUNCTION FIELD-EFFECT TRANSISTOR

SYMMETRICAL SILICON N-CHANNEL

Type A

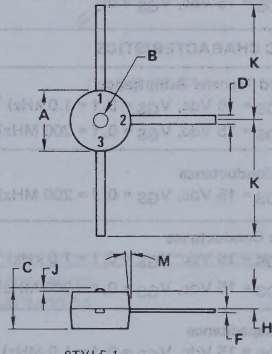


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Gate Current	I_G	10	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = −1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-30	–	–	Vdc
Gate Reverse Current (V_{GS} = −20 Vdc, V_{DS} = 0)	I_{GSS}	–	–	-1.0	nAdc
Gate-Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	–	–	-8.0	Vdc
Gate-Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	-1.0	–	-8.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	–	20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance	$\|y_{fs}\|$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) (1)		3000	–	8000	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		–	4000	–	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{is})$	–	500	–	μmhos
Output Conductance					μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz) (1)	$\|y_{os}\|$	–	25	–	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{os})$	–	125	–	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	1.0	–	pF
Common-Source Spot Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1000 ohms, f = 100 MHz)	NF	–	2.0	–	dB

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

MMT3903, MMT3904 (SILICON)
MMCM3903, MMCM3904 (CERAMIC PACKAGE)

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications and for complementary circuitry with PNP type MMT3905 and MMT3906 where high-density packaging is required.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- DC Current Gain Specified from 100 μAdc to 10 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 5.0 Vdc

MAXIMUM RATINGS

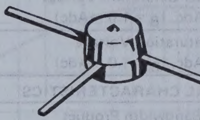
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector-Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W

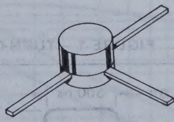
MICRO-T
NPN SILICON
SWITCHING AND AMPLIFIER
TRANSISTORS

MMT3903
MMT3904



CASE 28-01

MMCM3903
MMCM3904



CASE 176

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
Emitter-Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 100 µAdc, V_{CE} = 1.0 Vdc)	MMT3903		20	–	–	
	MMT3904		40	–	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MMT3903		35	–	–	
	MMT3904		70	–	–	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMT3903		50	–	150	
	MMT3904		100	–	300	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	–	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	–	–	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMT3903		250	–	–	
	MMT3904		300	–	–	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	–	8.0	pF
Noise Figure (I_C = 100 µAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms Noise Bandwidth – f = 10 Hz to 15.7 kHz)		NF	–	3.0	–	dB

SWITCHING TIME TEST CIRCUITS

FIGURE 1 – TURN-ON TIME

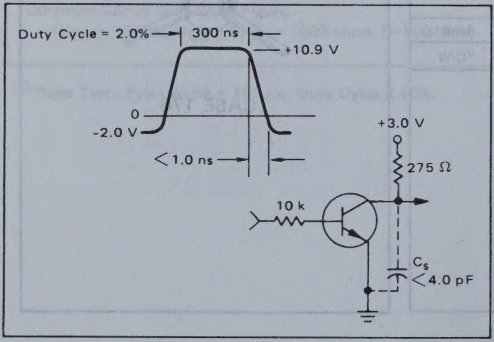


FIGURE 2 – TURN-OFF TIME

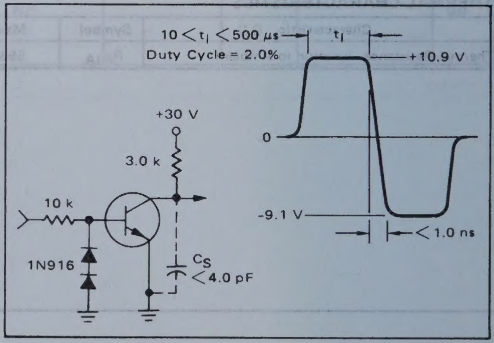
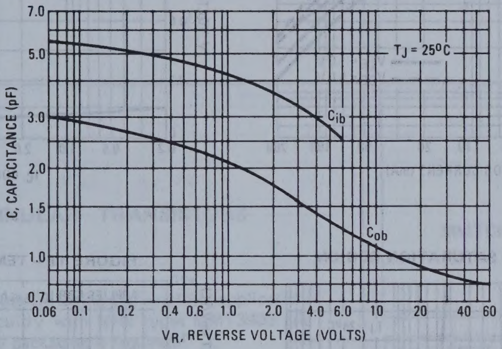


FIGURE 3 – CAPACITANCE



CURRENT-GAIN – BANDWIDTH PRODUCT

FIGURE 4 – MMT3903

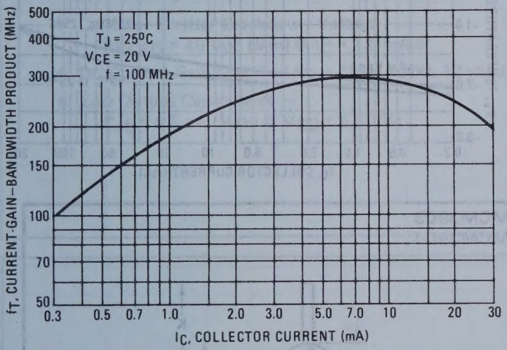


FIGURE 5 – MMT3904

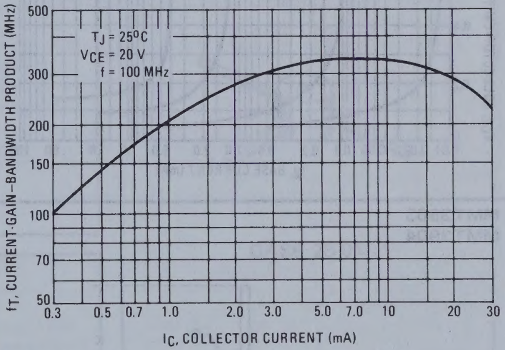


FIGURE 6 – TURN-ON TIME

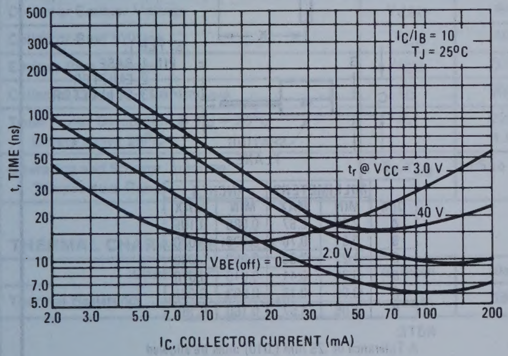


FIGURE 7 – TURN-OFF TIME

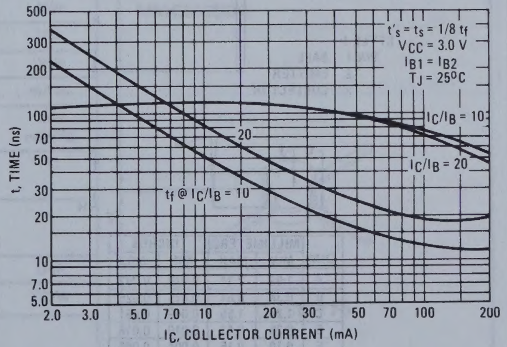


FIGURE 8 – DC CURRENT GAIN

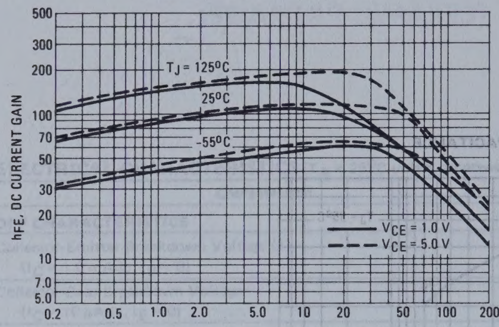


FIGURE 9 – "ON" VOLTAGE

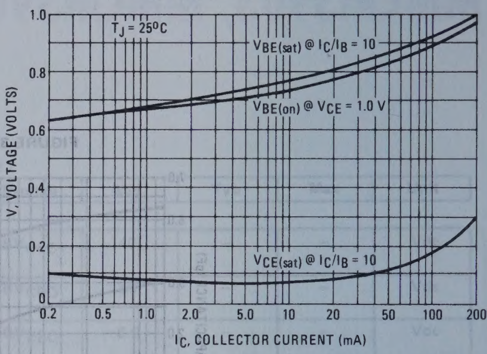


FIGURE 10 – COLLECTOR SATURATION REGION

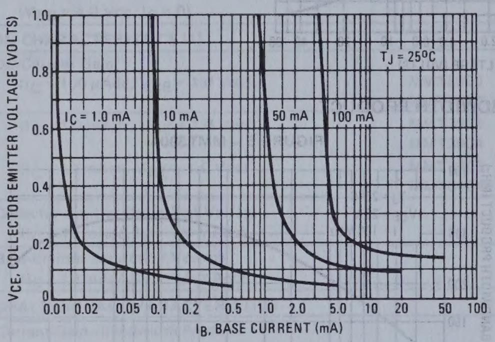
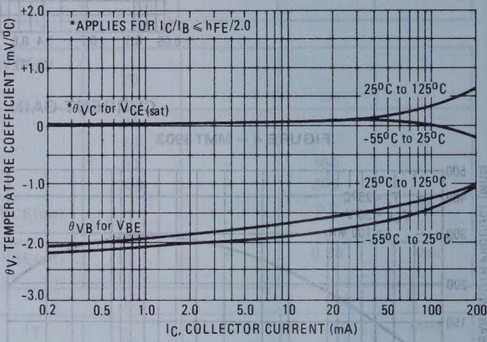
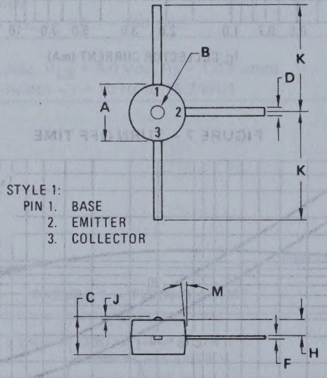


FIGURE 11 – TEMPERATURE COEFFICIENTS



MMT3903
MMT3904

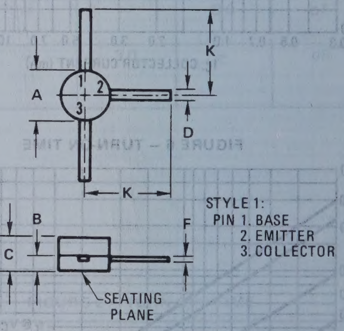


STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MMCM3903
MMCM3904



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176

MMT3905, MMT3906 (SILICON)
MMCM3905, MMCM3906 (CERAMIC PACKAGE)

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications and for complementary circuitry with NPN types MMT3903 and MMT3904 where high-density packaging is required.

- Space Saving Micro-Miniature Package
- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- DC Current Gain Specified from 100 μAdc to 10 mAdc
- Low Output Capacitance — C_{ob} = 4.5 pF (Max) @ V_{CB} = 5.0 Vdc

MICRO-T

PNP SILICON
SWITCHING AND AMPLIFIER
TRANSISTORS

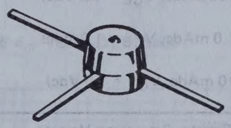
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 1.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

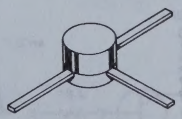
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	556	°C/W

MMT3905
MMT3906



CASE 28-01

MMCM3905
MMCM3906



CASE 176

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	50	nAdc
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	50	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				—
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)	MMT3905		30	—	—	
	MMT3906		60	—	—	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MMT3905		40	—	—	
	MMT3906		80	—	—	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMT3905		50	—	150	
	MMT3906		100	—	300	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	—	—	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (1)		f_T				MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMT3905		200	—	—	
	MMT3906		250	—	—	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	—	10	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, Noise Bandwidth — f = 10 Hz to 15.7 kHz)		NF	—	1.0	—	dB

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MMT3905, MMT3906, MMCM3905, MMCM3906 (continued)

FIGURE 1 – CURRENT-GAIN–BANDWIDTH PRODUCT

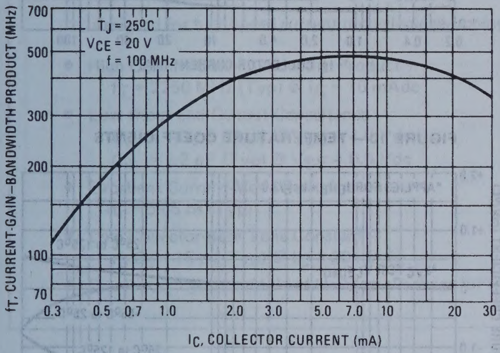


FIGURE 2 – CAPACITANCE

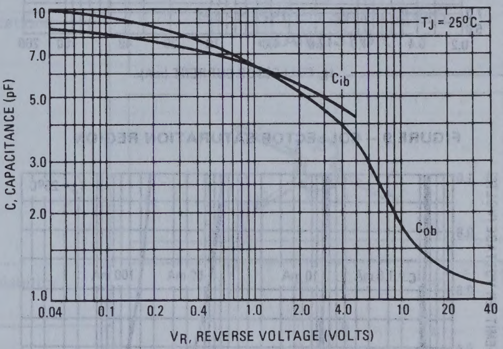


FIGURE 3 – TURN-ON TIME

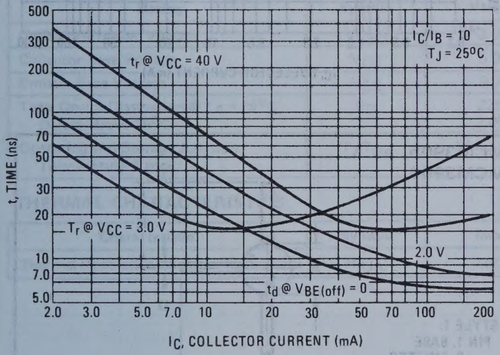


FIGURE 4 – TURN-OFF TIME

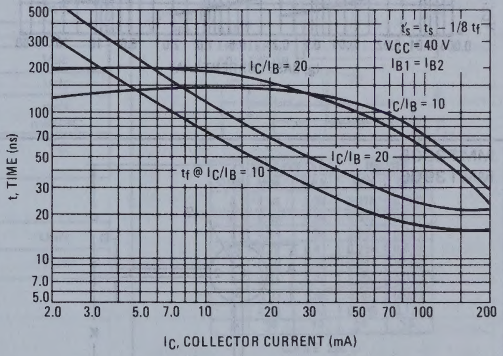
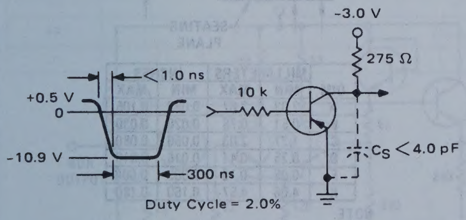
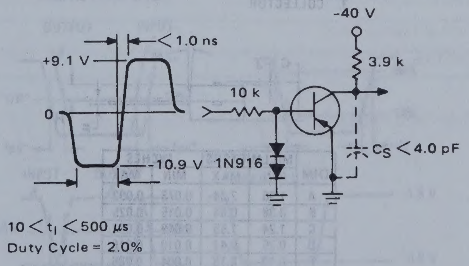


FIGURE 5 – TURN-ON SWITCHING CIRCUIT



-3.0 V
275 Ω
< 1.0 ns
+0.5 V
0
-10.9 V
10 k
300 ns
$C_S < 4.0$ pF
Duty Cycle = 2.0%

FIGURE 6 – TURN-OFF SWITCHING CIRCUIT



-40 V
< 1.0 ns
+9.1 V
3.9 k
10 k
0
-10.9 V
1N916
$C_S < 4.0$ pF
$10 < t_1 < 500$ µs
Duty Cycle = 2.0%

FIGURE 7 – DC CURRENT GAIN

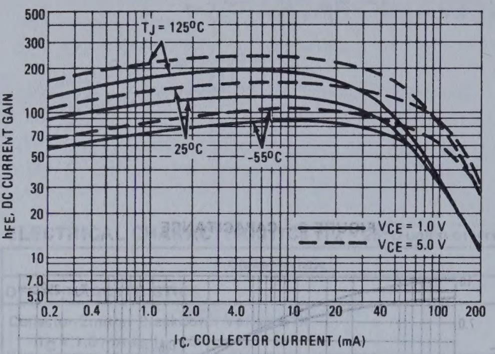


FIGURE 8 – "ON" VOLTAGES

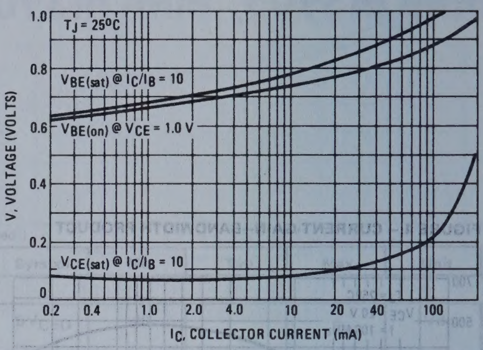


FIGURE 9 – COLLECTOR SATURATION REGION

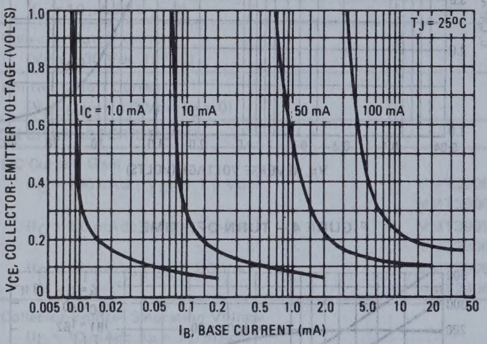
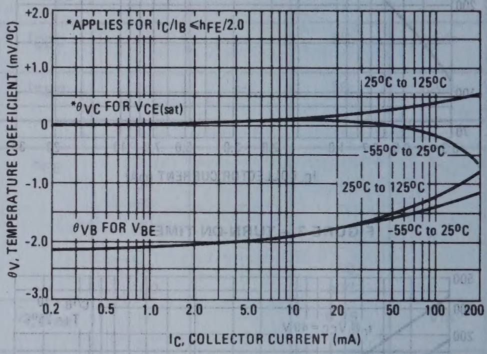
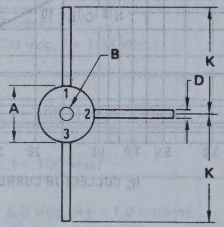


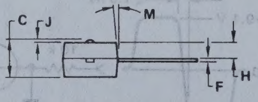
FIGURE 10 – TEMPERATURE COEFFICIENTS



MMT3905
MMT3906



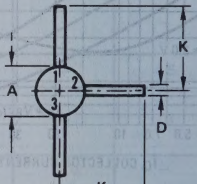
STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR



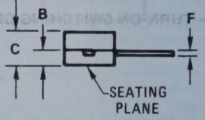
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MMCM3905
MMCM3906



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176

MMT3960 (SILICON)

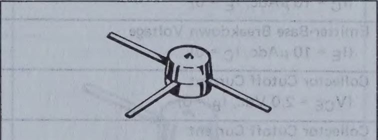
NPN SILICON ANNULAR TRANSISTOR

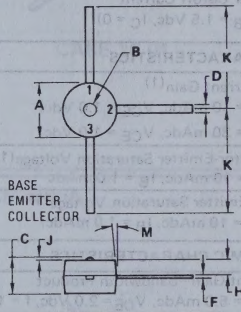
. . . designed for high-speed current-mode logic switching applications.

- High Current-Gain—Bandwidth Product — f_T = 2250 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance — C_{ob} = 1.3 pF (Typ) @ V_{CB} = 4.0 Vdc; C_{ib} = 1.2 pF (Typ) @ V_{BE} = 0.5 Vdc
- Excellent Current-Mode Performance — t_r = 0.65 ns (Typ)
- Low Collector-Base Time Constant — $r_b'C_c$ = 15 ps (Typ) @ I_C = 30 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-T▲

NPN SILICON HIGH-SPEED SWITCHING TRANSISTOR




B
K
D
A
1
2
3
K
M
C
J
H
F

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28

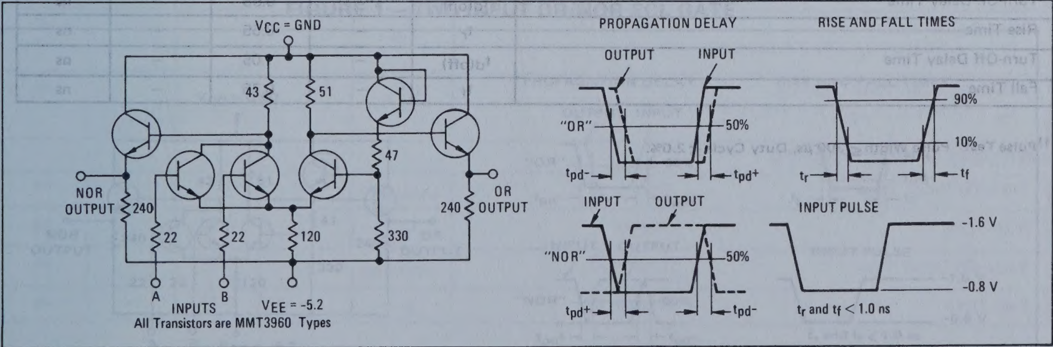
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	3.0	Vdc
Collector-Base Voltage	V_{CB}	5.0	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

FIGURE 1 – TWO INPUT OR/NOR ECL GATE


VCC = GND
43
51
47
240
22
22
120
330
240
NOR
OUTPUT
OR
OUTPUT
A
B
INPUTS
VEE = -5.2
All Transistors are MMT3960 Types
PROPAGATION DELAY
OUTPUT
INPUT
"OR"
50%
tpd-
tpd+
INPUT
OUTPUT
"NOR"
50%
tpd+
tpd-
RISE AND FALL TIMES
90%
10%
tr
tf
INPUT PULSE
-1.6 V
-0.8 V
tr and tf < 1.0 ns

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}(1)	3.0	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	5.0	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 2.0 Vdc, I_B = 0)	I_{CEO}	–	–	10	μAdc
Collector Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		100	–	200	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)		80	–	–	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc	$V_{CE(sat)}$	–	–	0.2	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	–	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product	f_T				MHz
(I_C = 5.0 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		–	2000	–	
(I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		–	2250	–	
(I_C = 30 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		1600	2600	–	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	1.3	2.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	1.2	3.0	pF
Collector-Base Time Constant (I_E = 30 mAdc, V_{CB} = 2.0 Vdc, f = 100 MHz)	$r_b C_c$	–	15	–	ps
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Delay Time	$t_{d(on)}$	–	0.95	–	ns
Rise Time	t_r	–	0.65	–	ns
Turn-Off Delay Time	$t_{d(off)}$	–	1.05	–	ns
Fall Time	t_f	–	0.75	–	ns

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT3960A (SILICON)
MMCM3960A (CERAMIC PACKAGE)

NPN SILICON ANNULAR TRANSISTOR

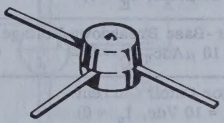
. . . designed for high-speed current-mode logic switching applications.

- High Current-Gain—Bandwidth Product — f_T = 2250 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance — C_{ob} = 1.3 pF (Typ) @ V_{CB} = 4.0 Vdc; C_{ib} = 1.2 pF (Typ) @ V_{BE} = 0.5 Vdc
- Excellent Current-Mode Performance — t_r = 0.75 ns (Typ)
- Low Collector-Base Time Constant — $r_b'C_c$ = 15 ps (Typ) @ I_C = 30 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE

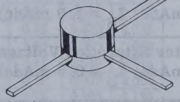
NPN SILICON
HIGH-SPEED SWITCHING
TRANSISTOR

MMT3960A



CASE 28-01

MMCM3960A



CASE 176

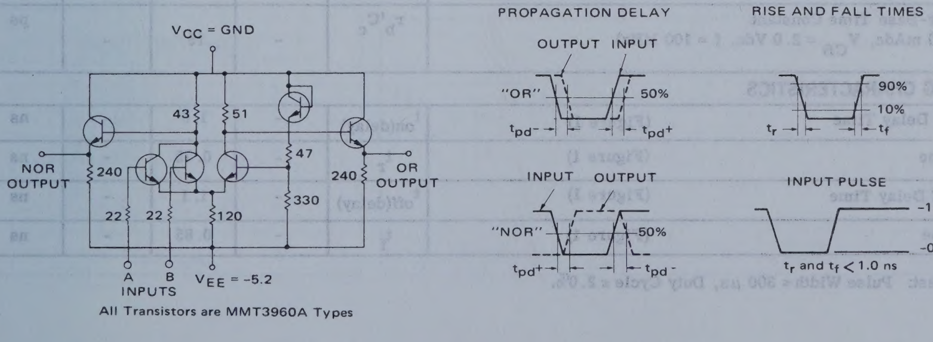
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	8.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	490	°C/W

FIGURE 1 – TWO INPUT OR/NOR ECL GATE



V_{CC} = GND
43
51
47
240
240
NOR OUTPUT
OR OUTPUT
22
22
120
330
A
B
INPUTS
V_{EE} = -5.2
PROPAGATION DELAY
OUTPUT
INPUT
"OR"
50%
$t_{pd}-$
$t_{pd}+$
INPUT
OUTPUT
"NOR"
50%
$t_{pd}+$
$t_{pd}-$
RISE AND FALL TIMES
90%
10%
t_r
t_f
INPUT PULSE
-1.6 V
-0.8 V
t_r and t_f < 1.0 ns

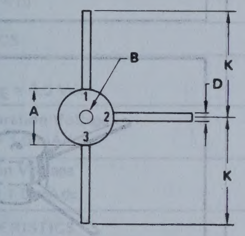
All Transistors are MMT3960A Types

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

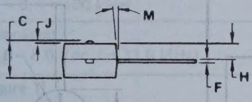
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	8.0	-		Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)	I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				-
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		30	-	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	-	200	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)		30	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	0.75	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (1)	f_T				MHz
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)		-	2000	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		-	2250	-	
(I_C = 30 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		1600	2500	-	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	1.3	2.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	1.2	3.0	pF
Collector-Base Time Constant (I_E = 30 mAdc, V_{CB} = 2.0 Vdc, f = 100 MHz)	$r_b'C_c$	-	15	-	ps
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (Figure 1)	$t_{on(delay)}$	-	1.0	-	ns
Rise Time (Figure 1)	t_r	-	0.75	-	ns
Turn-Off Delay Time (Figure 1)	$t_{off(delay)}$	-	1.1	-	ns
Fall Time (Figure 1)	t_f	-	0.85	-	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT3960A



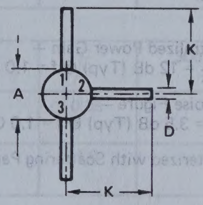
STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR



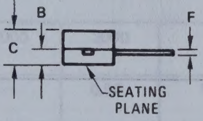
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MMCM3960A



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.03	2.67	0.080	0.105
B	0.51	0.76	0.020	0.030
C	1.27	2.03	0.050	0.080
D	0.25	0.41	0.010	0.016
F	0.08	0.15	0.003	0.006
K	4.06	4.57	0.160	0.180

NOTE:
A Tolerance of .25 mm (.010) must be allowed at point leads protrude from package for glass run over.

CASE 176

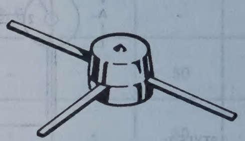
MMT8015 (SILICON)

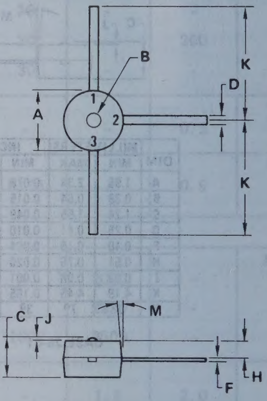
NPN SILICON RF SMALL–SIGNAL TRANSISTOR

. . . designed for low-noise, high-gain, small-signal microwave amplifiers. Ideal for microstrip circuits where high density packaging is required.

- Unneutralized Power Gain –
  G_{PE} = 12 dB (Typ) @ f = 1.0 GHz
- Low Noise Figure –
  NF = 3.5 dB (Typ) @ f = 1.0 GHz
- Characterized with Scattering Parameters

NPN SILICON MICRO–T RF SMALL–SIGNAL TRANSISTOR





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	15	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	–	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.35	–	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	1.0	–	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 250 MHz)	f_T	1000	2000	–	MHz
Collector-Base Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.50	1.0	pF
Collector-Base Time Constant (I_E = 6.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	4.0	–	ps
Noise Figure (1) (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 1.0 GHz)	NF	–	3.2	4.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (1) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, f = 1.0 GHz)	G_{pe}	6.0	7.5	–	dB
Common-Emitter Amplifier Power Gain (2) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, f = 1.0 GHz)	G_{pe}	10	13	–	dB

(1) Biased For Minimum Noise
(2) Biased For Optimum Gain

FIGURE 1 — POWER GAIN AND NOISE FIGURE TEST CIRCUIT

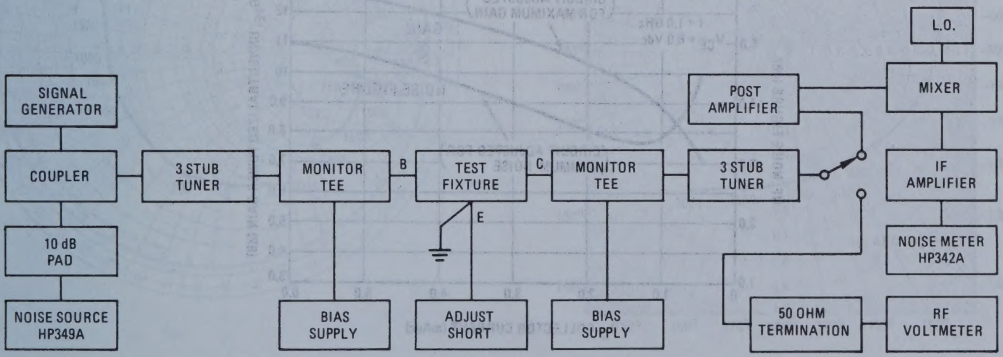

L.O.
SIGNAL GENERATOR
POST AMPLIFIER
MIXER
COUPLER
3 STUB TUNER
MONITOR TEE
B
TEST FIXTURE
C
MONITOR TEE
3 STUB TUNER
IF AMPLIFIER
E
10 dB PAD
NOISE METER HP342A
NOISE SOURCE HP349A
BIAS SUPPLY
ADJUST SHORT
BIAS SUPPLY
50 OHM TERMINATION
RF VOLTMETER

FIGURE 2 – COLLECTOR–BASE CAPACITANCE versus VOLTAGE

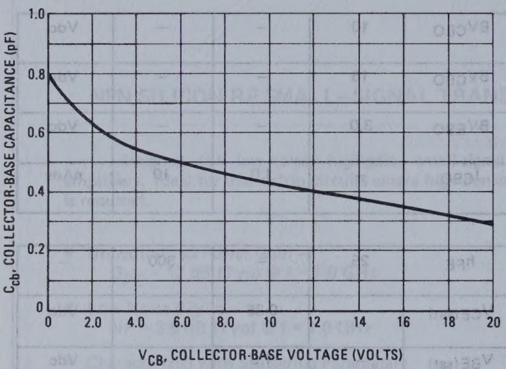


FIGURE 3 – CURRENT–GAIN – BANDWIDTH PRODUCT

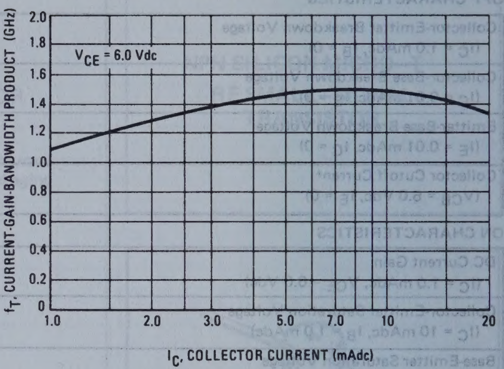


FIGURE 4 – NOISE FIGURE versus FREQUENCY

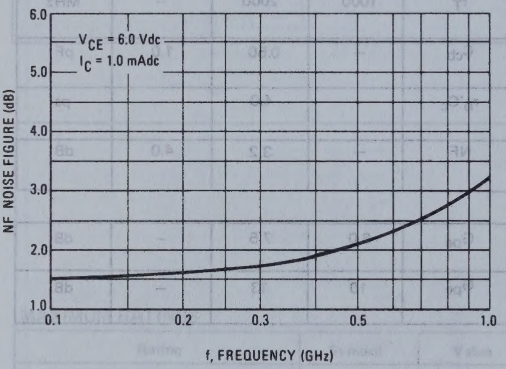


FIGURE 5 – UNNEUTRALIZED POWER GAIN versus FREQUENCY

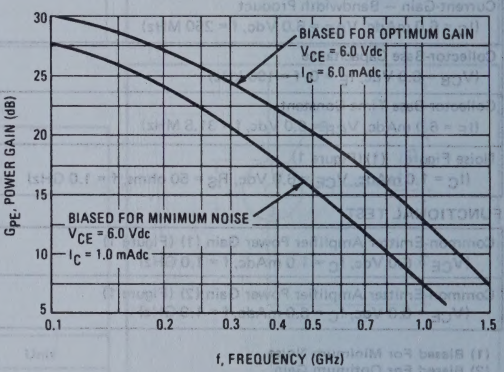
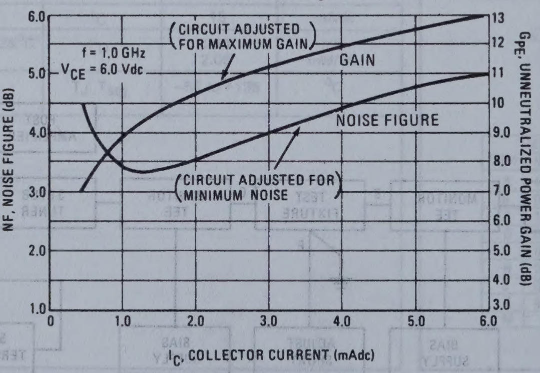


FIGURE 6 – NOISE FIGURE AND GAIN versus CURRENT
(See Test Circuit Figure 1)



S_{11}, S_{22}, INPUT AND OUTPUT REFLECTION COEFFICIENTS

V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc

FIGURE 7

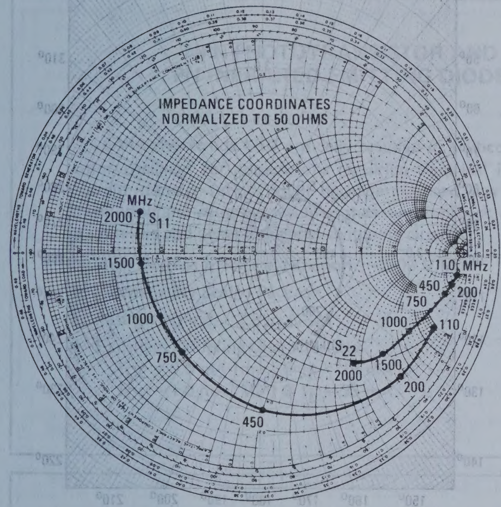
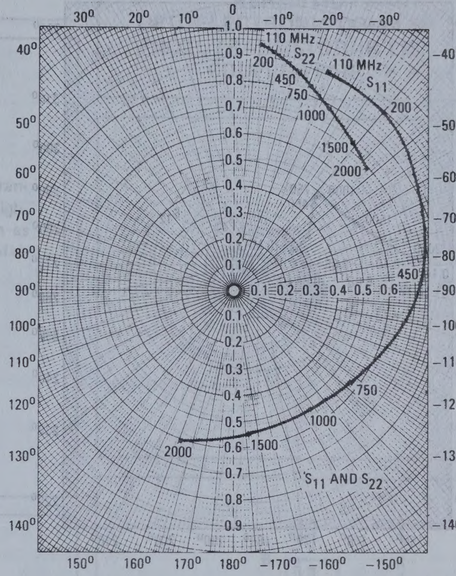


FIGURE 8



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc

FIGURE 9

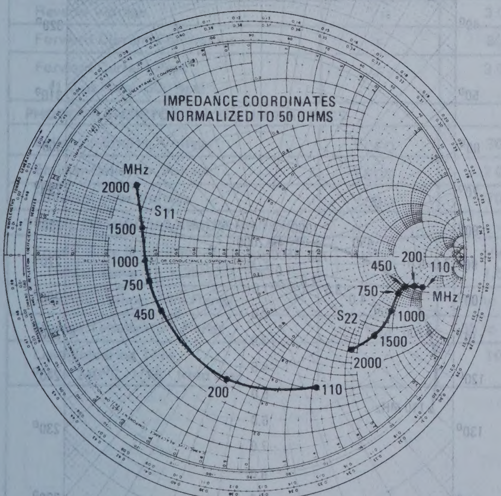
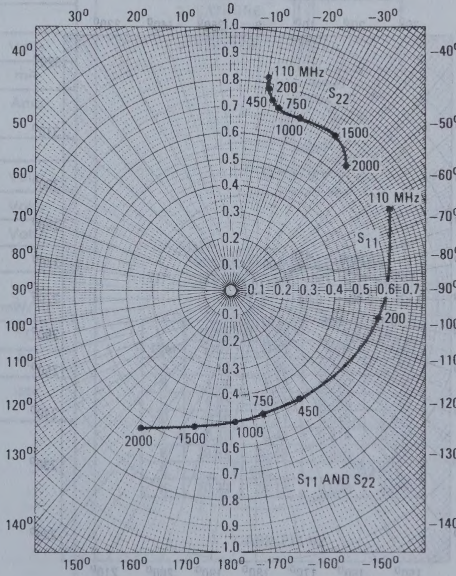


FIGURE 10



S_{12}, REVERSE TRANSMISSION COEFFICIENT S_{21}, FORWARD TRANSMISSION COEFFICIENT

V_{CC} = 6.0 Vdc, I_C = 1.0 mAdc, Z_G = Z_L = 50 Ohms

FIGURE 11

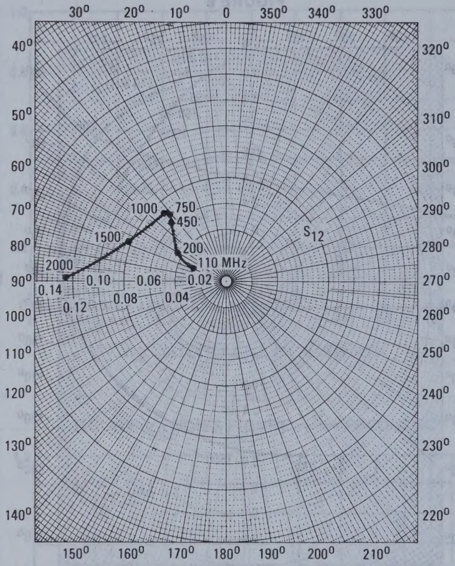
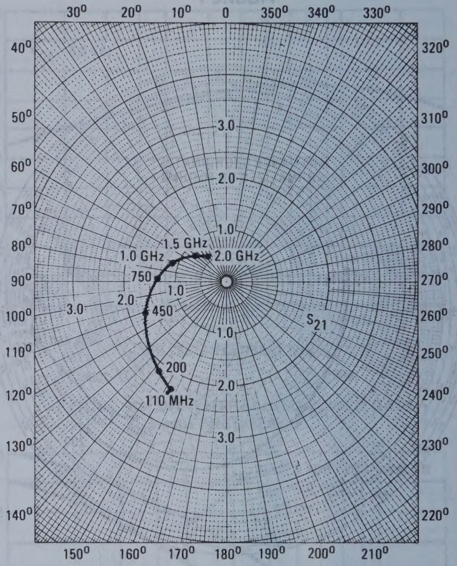


FIGURE 12



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, Z_G = Z_L = 50 Ohms

FIGURE 13

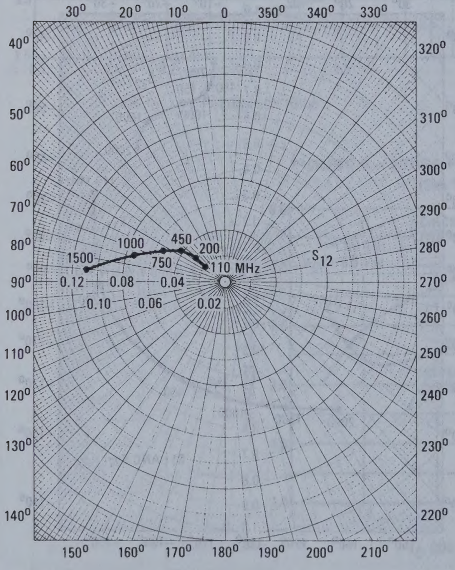
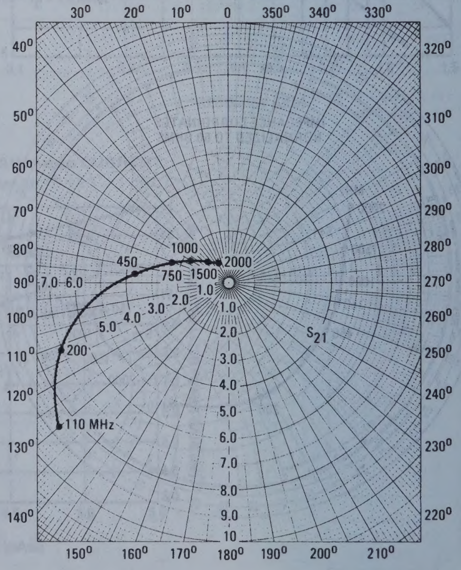


FIGURE 14



MOC2000

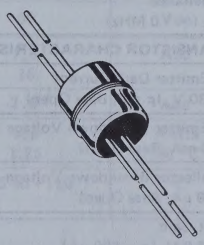
Advance Information

NPN PHOTOTRANSISTOR AND PN INFRARED EMITTING DIODE

. . . Gallium Arsenide LED optically coupled to a Silicon Photo Transistor designed for applications requiring electrical isolation, high-current transfer ratios, small package size and low cost; such as interfacing and coupling systems, phase and feedback controls, solid-state relays and general-purpose switching circuits.

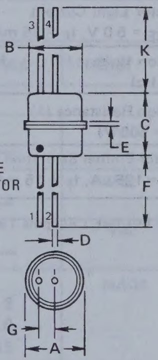
- High Voltage Electrical Isolation — 1500 V Min
- Hermetically Sealed Package
- Fast Switching — 2.8 μs (Typ)
- Excellent Coupling Characteristic
  I_{CL} = 0.5 mA (min) @ I_F = 15 mA
  I_{CL} = 1.6 mA (Min) @ I_F = 35 mA

HERMETIC OPTOELECTRONIC COUPLER PHOTOTRANSISTOR/IR LED COUPLED PAIR



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE MAXIMUM RATINGS			
Reverse Voltage	V_R	3.0	Volts
Forward Current-Continuous	I_F	80	mA
Forward Current-Peak (1.0 μs Pulse, 300 pps)	I_F	3.0	Amp
PHOTOTRANSISTOR MAXIMUM RATINGS			
Collector-Emitter Voltage	V_{CEO}	30	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Collector-Base Voltage	V_{CBO}	70	Volts
TOTAL DEVICE MAXIMUM RATINGS			
Total Device Dissipation @ T_A = 25°C Derate above T_A = 25°C	P_D	150 1.5	mW mW/°C
Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C
Lead Soldering Time T = 240°C, 1/16″ from case		10	sec



PIN 1. ANODE
2. CATHODE
3. COLLECTOR
4. EMITTER

NOTE:
POLARITY DOT ON PACKAGE DENOTES PIN 1.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.70	4.95	0.185	0.195
B	4.06	4.32	0.160	0.170
C	4.95	5.21	0.195	0.205
D	0.38	0.51	0.015	0.020
E	0.36	0.46	0.014	0.018
F	26.67	30.48	1.050	1.200
G	1.27 BSC		0.050 BSC	
K	20.32	24.13	0.800	0.950

CASE 271-02

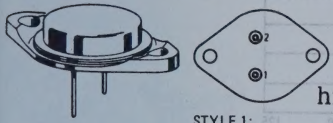
This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
LED CHARACTERISTICS					
Reverse Leakage Current ($V_R = 3.0$ V, $R_L = 1.0$ M Ω)	I_R	–	–	100	µA
Forward Voltage ($I_F = 50$ mA)	V_F	–	–	1.5	Volts
Input Capacitance ($V_R = 0$, f = 1.0 MHz)	C_i	–	150	–	pF
PHOTOTRANSISTOR CHARACTERISTICS					
Collector-Emitter Dark Current ($V_{CE} = 30$ V, $I_F = 0$, Base Open)	I_{CEO}	–	–	25	nA
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mA, Base Open)	BV_{CEO}	30	–	–	Volts
Emitter-Collector Breakdown Voltage ($I_E = 100$ µA, Base Open)	BV_{ECO}	7.0	–	–	Volts
DC Current Gain ($V_{CE} = 5.0$ V, $I_C = 100$ µA)	h_{FE}	–	200	–	–
COUPLED CHARACTERISTICS					
Collector Light Current ($V_{CE} = 50$ V, $I_F = 15$ mA)	I_{CL_1}	0.5	–	–	mA
Collector Light Current ($V_{CE} = 5.0$ V, $I_F = 35$ mA)	I_{CL_2}	1.6	–	–	mA
Isolation Voltage (1) (60 Hz)	–	1500	–	–	Volts
Isolation Resistance (1) (V = 500 V)	–	–	10^{13}	–	Ohms
Collector-Emitter Saturation Voltage ($I_C = 125$ µA, $I_F = 15$ mA)	$V_{CE(sat)}$	–	–	0.3	Volts

(1) For this test, LED pins 1 and 2 are common, and PHOTOTRANSISTOR pins 3 and 4 are common.

MP110 (GERMANIUM)



CASE 11

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

PNP germanium power transistor designed for high-gain power amplification in the audio range.

MAXIMUM RATINGS ($T_C = 25^oC$ unless otherwise noted)

Rating	Symbol	MP110	Unit
Collector-Emitter Voltage	V_{CEX}	65	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Collector Current-Continuous Peak	I_C	7.0 15	Adc
Base Current	I_B	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	106 1.25	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, $V_{BE(off)}$ = 2 Vdc)	BV_{CEX}	65	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 0.6 Adc, R_{BE} = 68 ohms)	BV_{CER}	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 0.2 Adc, V_{BE} = 0)	BV_{CES}	50	—	—	Vdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, $T_J = 75^oC$)	I_{CBO}	— — —	— — —	0.2 2.0 15	mAdc
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)	I_{EBO}	—	—	8.0	mAdc
Floating Potential (V_{CB} = 40 Vdc, I_E = 0)	V_{FL}	—	—	0.8	Vdc
ON CHARACTERISTICS					
DC Current Gain (See Note) (I_C = 50 mAdc, V_{CE} = 2 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	60 74	— —	— 250	—
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	—	—	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	f_T	—	320	—	kHz

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

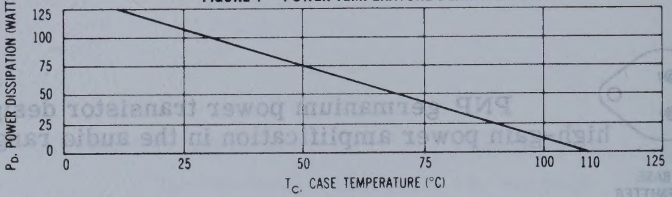


FIGURE 2 — DC CURRENT GAIN

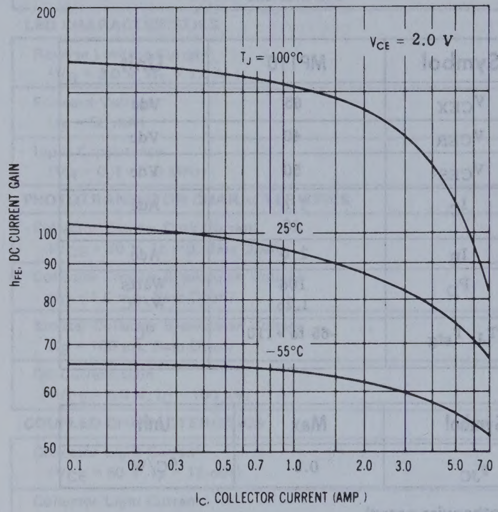


FIGURE 3 — TRANSCONDUCTANCE

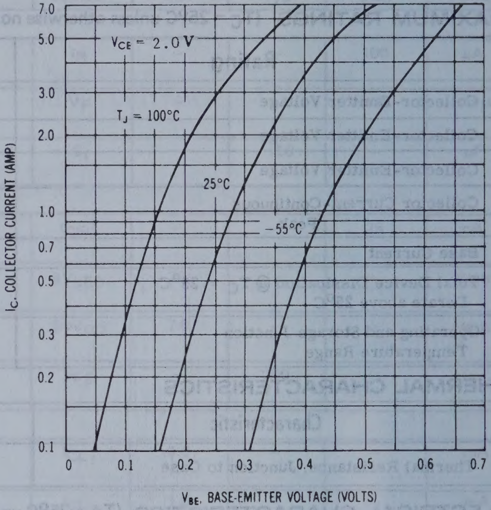


FIGURE 4 — ACTIVE REGION SAFE OPERATING AREA

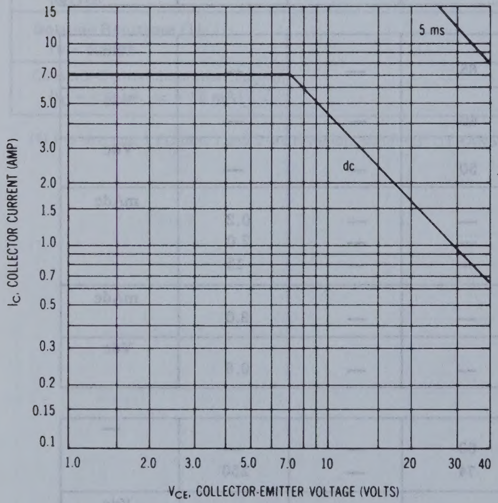
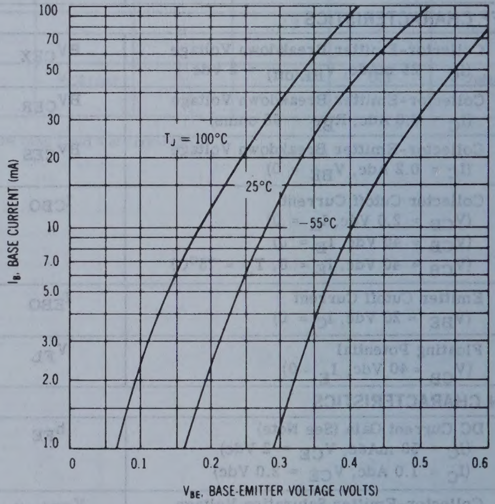


FIGURE 5 — INPUT ADMITTANCE



NOTE: Transistors are color coded to identify gain ranges as shown. No guarantee is made of gain distribution. $I_C = 1$ Adc, $V_{CE} = 2$ Vdc

COLOR CODE	h_{FE}	
	Min.	Max.
red	74	111
orange	100	133
yellow	119	164
green	145	200
blue	179	250

MP110B (GERMANIUM)

PNP GERMANIUM POWER SWITCHING TRANSISTOR

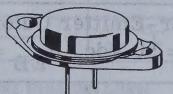
. . . designed for high-current switching applications requiring low saturation voltages, fast switching times and good safe operating area.

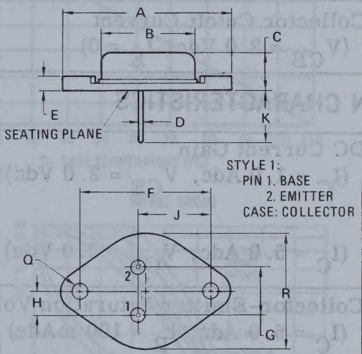
- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltage – $V_{CE(sat)}$ = 0.5 Vdc @ I_C = 5.0 Adc

25 AMPERE

PNP ADE GERMANIUM
POWER TRANSISTOR

90 VOLTS
106 WATTS





A
B
C
E
D
K
SEATING PLANE
F
J
Q
2
1
H
R
G

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	8.13	10.67	0.320	0.420
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

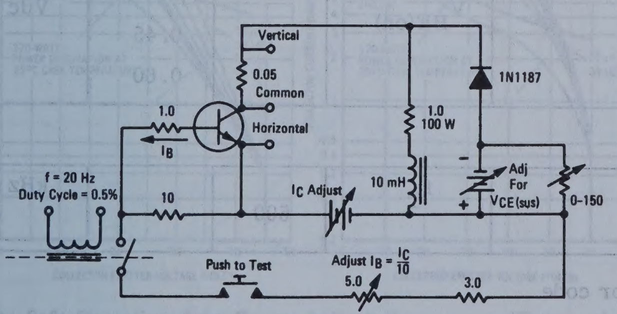
CASE 11A

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current - Continuous	I_C	25	Adc
Base Current - Continuous	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W



Vertical
0.05
Common
1.0
Horizontal
I_B
1N1187
1.0
100 W
10 mH
Adj
For
$V_{CE(sus)}$
0-150
I_C Adjust
f = 20 Hz
Duty Cycle = 0.5%
10
Push to Test
Adjust $I_B = \frac{I_C}{10}$
5.0
3.0

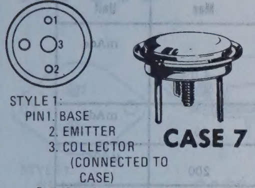
FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)		BV_{CEO}	40	-	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 Adc) (See Figure 1)		$V_{CE(sus)}$	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 mAdc, I_C = 0)		BV_{EBO}	2.0	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 50 Vdc, R_{EB} = 100 Ohms)		I_{CER}	-	10	mAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, $V_{BE(off)}$ = 0.2 Vdc)		I_{CEX}	-	20	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	200	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)*	Red	h_{FE}	65	120	-
	Green		100	200	
	Blue		150	300	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			55	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	-	0.45	Vdc
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			-	0.60	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)		f_T	500	-	kHz

*For desired h_{FE} range, specify color code.

MP500 thru **MP502** (GERMANIUM)
MP504 thru **MP506**



PNP germanium power transistors for high-gain, high-power amplifier and switching applications in high reliability industrial equipment.

MAXIMUM RATINGS

Rating	Symbol	MP500 MP504	MP501 MP505	MP502 MP506	Unit
Collector-Base Voltage	V_{CB}	45	60	75	Volts
Collector-Emitter Voltage	V_{CES}	45	60	75	Volts
Collector-Emitter Voltage	V_{CEO}	30	45	60	Volts
Emitter-Base Voltage	V_{EB}	25	30	40	Volts
Collector Current	I_C	60	60	60	Amp
Power Dissipation at $T_C = 25^oC$	P_D	170	170	170	Watts
Junction Temperature Range	T_J	← -65 to + 110 →			^oC

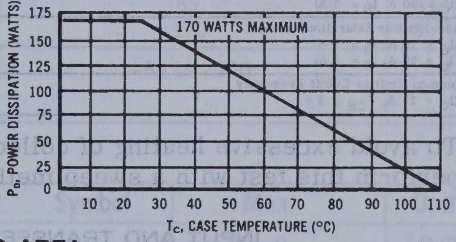
POWER DERATING

The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

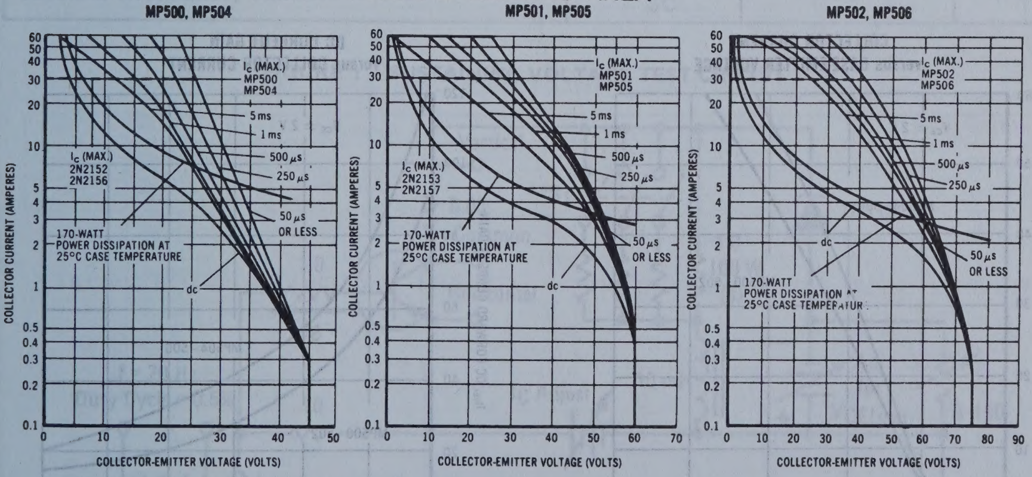
This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$

POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO1}				mAdc
(V_{CB} = -45 V, I_E = 0)	MP500 MP504		—	0.9	4.0	
(V_{CB} = -60 V, I_E = 0)	MP501 MP505		—	0.9	4.0	
(V_{CB} = -75 V, I_E = 0)	MP502 MP506		—	0.9	4.0	
Collector-Base Cutoff Current (V_{CB} = V_{CBmax}, I_E = 0, T_C = +71°C)		I_{CBO}	—	4.0	15	mAdc
Collector-Base Cutoff Current (V_{CB} = -2 V, I_E = 0)		I_{CBO}	—	80	200	μAdc
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = -25 V, I_C = 0)	MP500 MP504		—	0.2	4.0	
(V_{EB} = -30 V, I_C = 0)	MP501 MP505		—	0.2	4.0	
(V_{EB} = -40 V, I_C = 0)	MP502 MP506		—	0.2	4.0	
Emitter-Base Cutoff Current (V_{EB} = $V_{EB\,max}$, I_C = 0, T_C = +71°C)		I_{EBO}	—	2.7	15	mAdc
Collector-Emitter Breakdown Voltage (1)		BV_{CES}				Vdc
(I_C = 300 mA, V_{EB} = 0)	MP500 MP504		-45	—	—	
	MP501 MP505		-60	—	—	
	MP502 MP506		-75	—	—	
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 1.0 A, I_B = 0)	MP500 MP504		-30	—	—	
	MP501 MP505		-45	—	—	
	MP502 MP506		-60	—	—	
Floating Potential		V_{EBF}				Vdc
(V_{CB} = 45 V, I_E = 0)	MP500 MP504		—	—	1.0	
(V_{CB} = 60 V, I_E = 0)	MP501 MP505		—	—	1.0	
(V_{CB} = 75 V, I_E = 0)	MP502 MP506		—	—	1.0	
DC Current Transfer Ratio		h_{FE1}				—
(I_C = 15 A, V_{CE} = 2 V)	MP500 through MP502		30	47	60	
	MP504 through MP506		50	63	100	
(I_C = 50 A, V_{CE} = 2 V)	All Types	h_{FE}	12	20	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 15 A, I_B = 1 A)			—	0.11	0.2	
(I_C = 50 A, I_B = 5 A)			—	0.2	0.45	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 15 A, I_B = 1 A)			—	0.7	1.5	
(I_C = 50 A, I_B = 5 A)			—	2.0	2.5	
Common Emitter Cutoff Frequency (I_C = 15 A, V_{CE} = 2 V)		$f_{\alpha e}$	2.0	3.6	—	kHz

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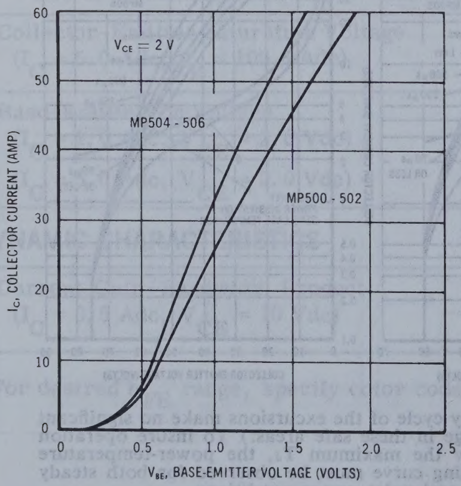
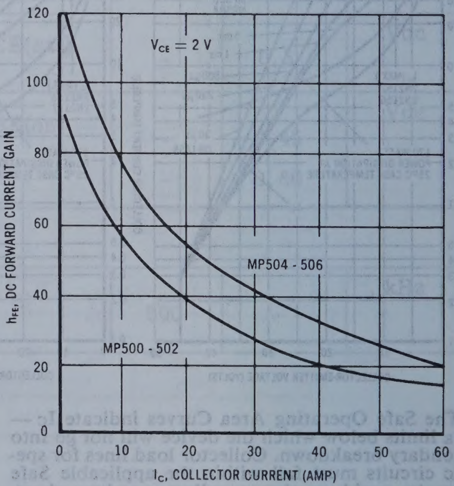
(1) To avoid excessive heating of collector junction, perform this test with a sweep method.

INPUT AND TRANSFER CHARACTERISTICS

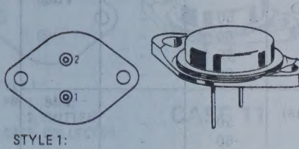
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



MP600 (GERMANIUM)
thru
MP603



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

CASE 11A

PNP Germanium power transistors designed for high-current switching applications requiring low saturation voltages, short switching times and good sustaining voltage capability.

- Alloy Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)} = 0.75$ Vdc (Max) @ $I_C = 25$ Adc
  $V_{BE(sat)} = 1.2$ Vdc (Max) @ $I_C = 25$ Adc

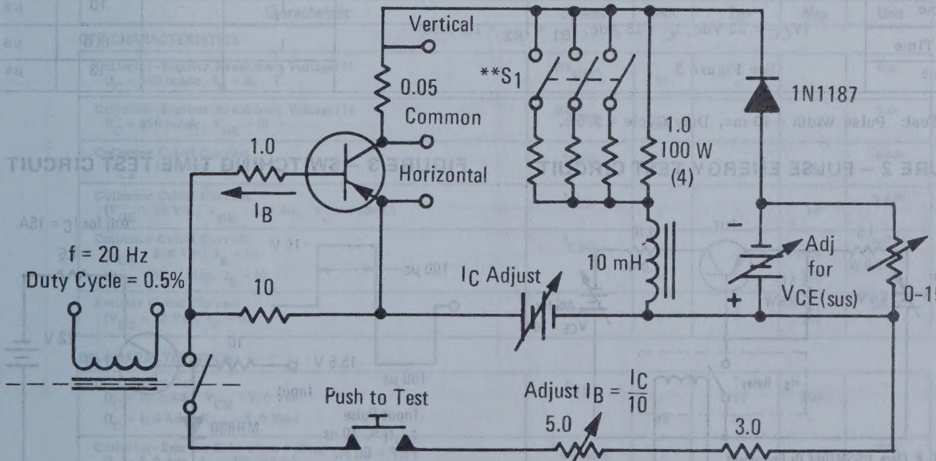
MAXIMUM RATINGS

Rating	Symbol	MP600	MP601	MP602	MP603	Unit
Collector-Emitter Voltage	V_{CEO}	50	60	70	80	Vdc
Collector-Base Voltage	V_{CB}	75	75	90	90	Vdc
Emitter-Base Voltage	V_{EB}	1.5				Vdc
Collector Current - Continuous	I_C	25				Adc
Base Current - Continuous	I_B	5.0				Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	85 1.0				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



Vertical
0.05
Common
Horizontal
1.0
I_B
**S_1
1.0
100 W
(4)
1N1187
10 mH
–
+
Adj
for
$V_{CE(sus)}$
0-150
f = 20 Hz
Duty Cycle = 0.5%
10
I_C Adjust
Push to Test
Adjust $I_B = \frac{I_C}{10}$
5.0
3.0

**Close Switch S_1 for I_C = 25A Test

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

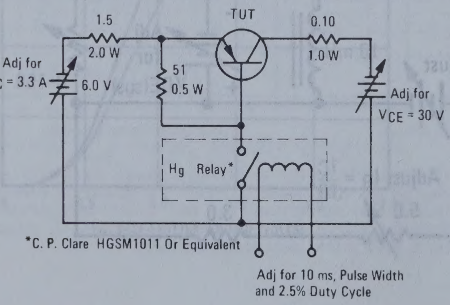
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}			Vdc
MP600		50	-	
MP601		60	-	
MP602		70	-	
MP603		80	-	
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 5.0 Adc)	$V_{CE(sus)}$			Vdc
MP600		50	-	
MP601		60	-	
MP602		70	-	
MP603		80	-	
(I_C = 25 Adc) MP600		30	-	
MP601		40	-	
MP602		40	-	
MP603		50	-	
Emitter-Base Breakdown Voltage (I_E = 100 mAdc, I_C = 0)	BV_{EBO}	1.5	-	Vdc
Floating Potential (V_{CB} = 60 Vdc, I_E = 0)	V_{EBF}	-	0.4	Vdc
Collector Cutoff Current	I_{CEX}			mAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 0.2 Vdc) MP600, MP601		-	10	
(V_{CE} = 90 Vdc, $V_{BE(off)}$ = 0.2 Vdc) MP602, MP603		-	10	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μAdc
Emitter Cutoff Current (V_{EB} = 0.5 Vdc, I_C = 0)	I_{EBO}	-	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	50	-	-
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 1.25 Adc)	$V_{CE(sat)}$	-	0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 1.25 Adc)	$V_{BE(sat)}$	-	1.2	Vdc
Emitter-Base On Voltage (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$V_{EB(on)}$	-	0.6	Vdc
Pulse Energy Test (See Figure 2) (1) (I_C = 3.3 Adc, V_{CE} = 30 Vdc)	PET	1.0	-	Joule

SWITCHING CHARACTERISTICS

Rise Time	(V_{CC} = 22 Vdc, I_C = 15 Adc, I_{B1} = I_{B2} = 1.5 Adc) See Figure 3	t_r	-	10	μs
Storage Time		t_s	-	6.0	μs
Fall Time		t_f	-	13	μs

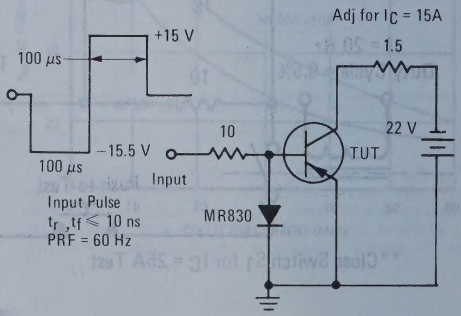
(1) Pulse Test: Pulse Width = 10 ms, Duty Cycle = 2.5%.

FIGURE 2 – PULSE ENERGY TEST CIRCUIT

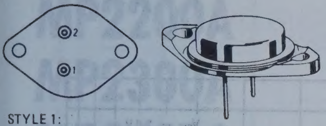

1.5
2.0 W
TUT
0.10
1.0 W
Adj for
I_C = 3.3 A
6.0 V
51
0.5 W
Adj for
V_{CE} = 30 V
Hg Relay*
Adj for 10 ms, Pulse Width
and 2.5% Duty Cycle

*C. P. Clare HGSM1011 Or Equivalent

FIGURE 3 – SWITCHING TIME TEST CIRCUIT


Adj for I_C = 15A
+15 V
100 μs
1.5
−15.5 V
100 μs
10
22 V
TUT
Input
Input Pulse
t_r ,t_f ⩽ 10 ns
PRF = 60 Hz
MR830

MP1613 (GERMANIUM)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

CASE 11

Medium-current germanium PNP power transistor, designed for use in 12 Volt vertical deflection circuits in television receivers; features: high breakdown voltage, low leakage current, and low saturation voltage.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	75	Vdc
Collector-Emitter Voltage	V_{CES}	90	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	50	Vdc
Collector Current — Continuous — Peak	I_C	7.0 15	Adc Adc
Base Current — Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

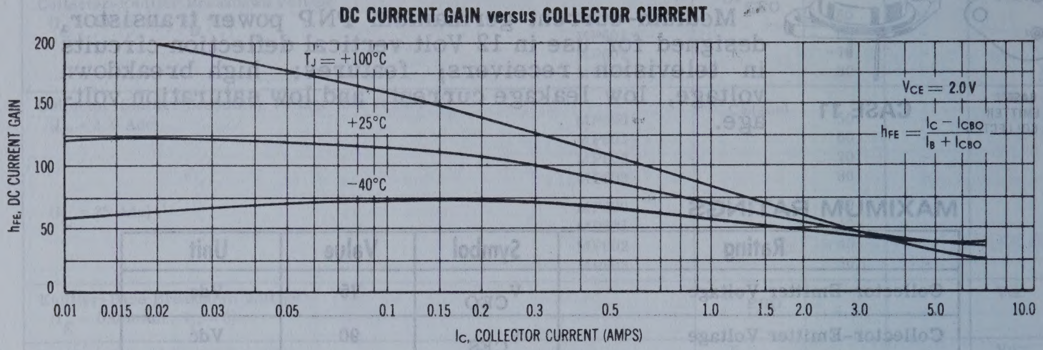
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

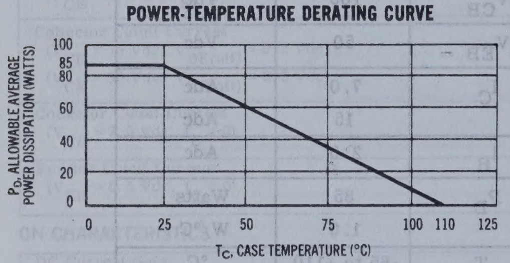
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 300 mAdc, I_B = 0)	BV_{CEO}	75	-	-	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 250 mAdc, V_{BE} = 0)	BV_{CES}	90	-	-	Vdc
Collector Cutoff Current (V_{CE} = 37.5 Vdc, I_B = 0)	I_{CEO}	-	-	30	mAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, V_{BE} = 1.0 Vdc, T_C = +100°C)	I_{CEX}	-	-	10	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0) (V_{CB} = V_{CB} max, I_E = 0)	I_{CBO}	- -	- -	0.06 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 12 Vdc, I_C = 0)	I_{EBO}	-	-	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	- 40	120 70	200 -	-
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)	$V_{CE(sat)}$	-	-	0.25	Vdc

(1) Sweep Test: 1/2 sine wave, 60 Hz.

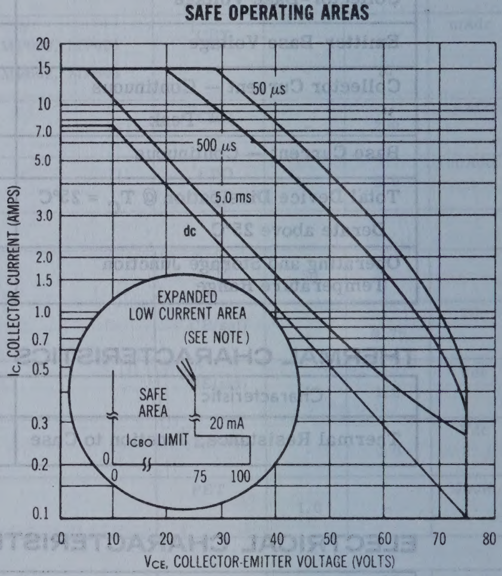


DC CURRENT GAIN versus COLLECTOR CURRENT

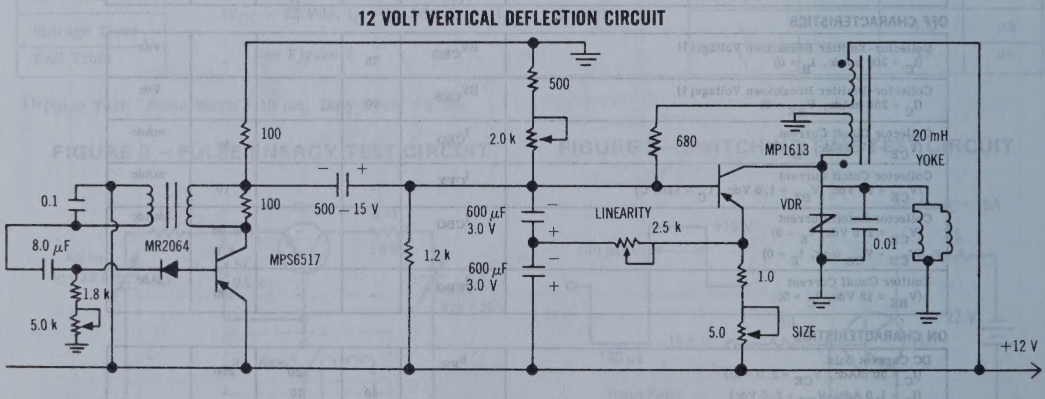


POWER-TEMPERATURE DERATING CURVE

NOTE: — The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.



SAFE OPERATING AREAS



12 VOLT VERTICAL DEFLECTION CIRCUIT

500
2.0 k
100
100
500 — 15 V
600 µF 3.0 V
600 µF 3.0 V
1.2 k
0.1
8.0 µF
MR2064
MPS6517
1.8 k
5.0 k
680
MP1613
20 mH YOKE
LINEARITY
2.5 k
VDR
0.01
1.0
5.0
SIZE
+12 V

MP2000A (GERMANIUM)
MP2100A
MP2200A
MP2300A
MP2400A

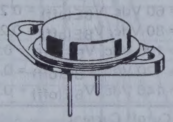
PNP GERMANIUM POWER TRANSISTORS

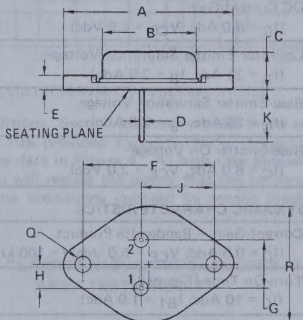
. . . designed for high-voltage switching, and power converter applications.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages —
  $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 25 Adc
  $V_{BE(sat)}$ = 1.0 Vdc (Max) @ I_C = 25 Adc
- Fast Switching Times —
  t_{on} = 11 μs (Typ) @ I_C = 10 Adc
  t_{off} = 21 μs (Typ) @ I_C = 10 Adc
- Guaranteed Excellent Safe Operating Area

25 AMPERES ADE
POWER TRANSISTORS

30-120 VOLTS
106 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	8.13	10.67	0.320	0.420
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11A

(1) For devices with Lugs (TO-41) contact your local Motorola sales office.

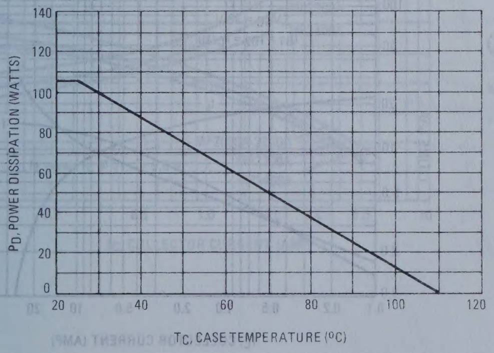
MAXIMUM RATINGS

Rating	Symbol	MP2000A	MP2100A	MP2200A	MP2300A	MP2400A	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	2.0					Vdc
Collector Current-Continuous	I_C	25					Adc
Base Current — Continuous	I_B	5.0					Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25					Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +110					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	MP2000A	BV_{CEO}	30	–	–	Vdc
	MP2100A		60	–	–	
	MP2200A		80	–	–	
	MP2300A		100	–	–	
	MP2400A		120	–	–	
Collector-Emitter Sustinaing Voltage (Figure 7) (I_C = 8.0 Adc)	MP2000A	$V_{CE(sus)}$	60	–	–	Vdc
	MP2100A		80	–	–	
	MP2200A		90	–	–	
	MP2300A		100	–	–	
	MP2400A		120	–	–	
(I_C = 25 Adc)	MP2000A		60	–	–	
	MP2100A		70	–	–	
	MP2200A		75	–	–	
	MP2300A		80	–	–	
	MP2400A		90	–	–	
Emitter-Base Breakdown Voltage (I_E = 0.5 Adc, I_C = 0)		BV_{EBO}	2.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2000A	I_{CEX}	–	–	10	mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2100A		–	–	10	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2200A		–	–	10	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2300A		–	–	10	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2400A		–	–	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc ,T_C = 85°C)	MP2000A		–	–	25	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc ,T_C = 85°C)	MP2100A		–	–	25	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc ,T_C = 85°C)	MP2200A		–	–	25	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc ,T_C = 85°C)	MP2300A		–	–	25	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc ,T_C = 85°C)	MP2400A		–	–	25	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	–	–	200	µAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	25	–	–	–
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{CE(sat)}$	–	–	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	–	–	1.0	Vdc
Base-Emitter On Voltage (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	–	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc, f = 100 kHz)		f_T	–	430	–	kHz
Turn-On Time (Figure 2) (I_C = 10 Adc, I_{B1} = 1.0 Adc)		t_{on}	–	11	–	µs
Turn-Off Time (Figure 2) (I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)		t_{off}	–	21	–	µs

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

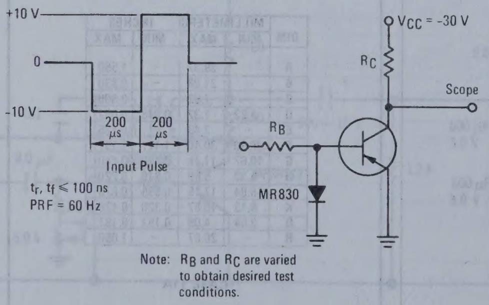


FIGURE 3 – SWITCHING TIMES

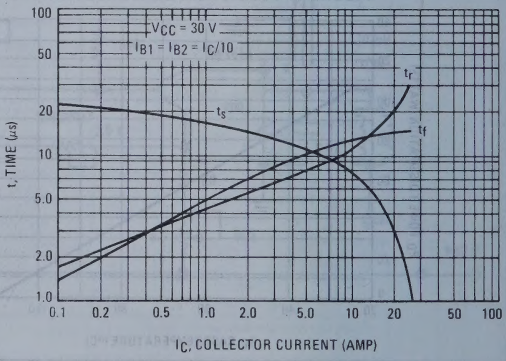


FIGURE 4 – THERMAL RESPONSE

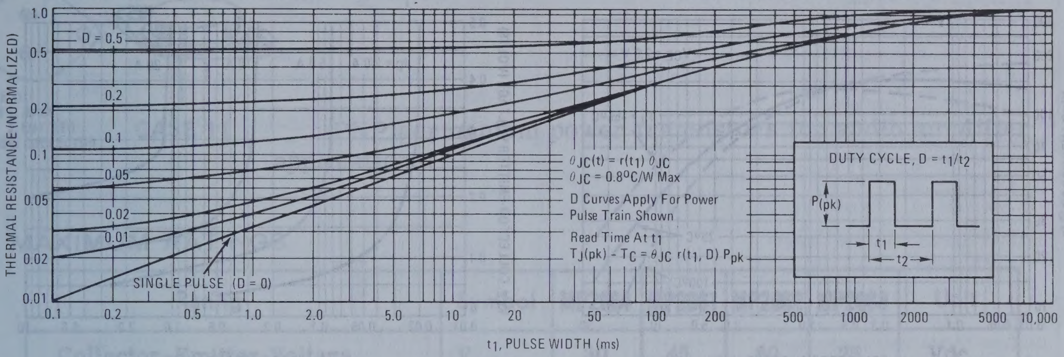


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

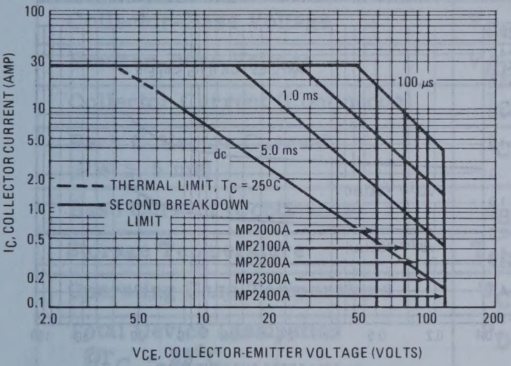
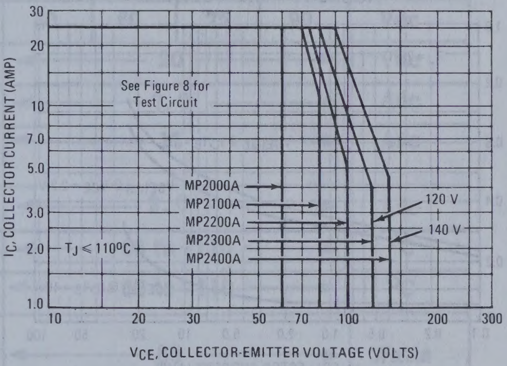


FIGURE 6 – CLAMPED INDUCTIVE SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 110^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 110^\circ C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

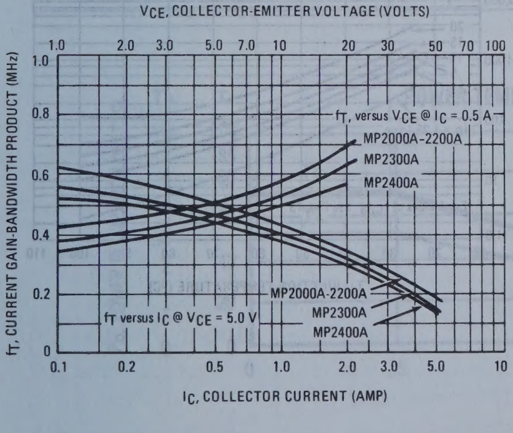


FIGURE 8 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT

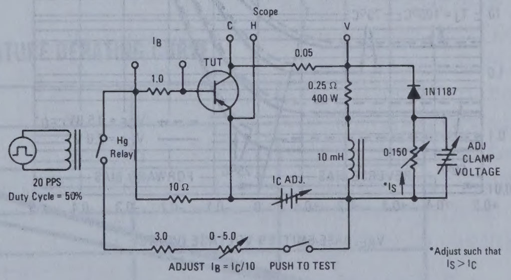

Scope
C
H
V
I_B
TUT
1.0
0.05
0.25 Ω 400 W
1N1187
Hg Relay
20 PPS
Duty Cycle = 50%
10 mH
0-150
*I_S
ADJ CLAMP VOLTAGE
10 Ω
I_C ADJ.
3.0
0 - 5.0
ADJUST $I_B = I_C/10$
PUSH TO TEST
*Adjust such that $I_S > I_C$

FIGURE 9 – DC CURRENT GAIN

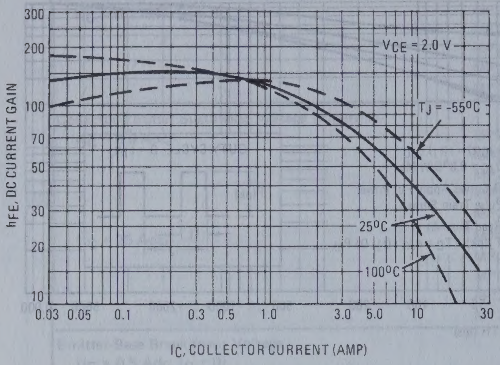


FIGURE 10 – COLLECTOR SATURATION REGION

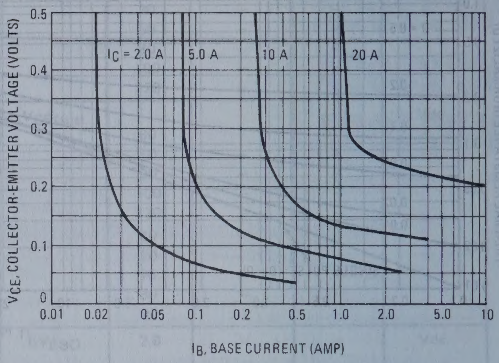


FIGURE 11 – "ON" VOLTAGES

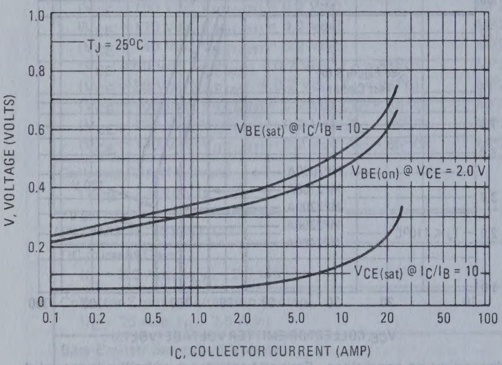


FIGURE 12 – TEMPERATURE COEFFICIENTS

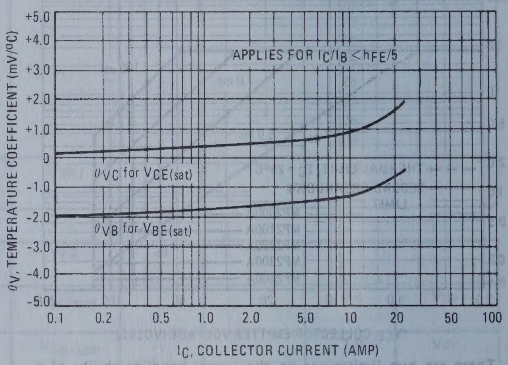


FIGURE 13 – COLLECTOR CUTOFF REGION

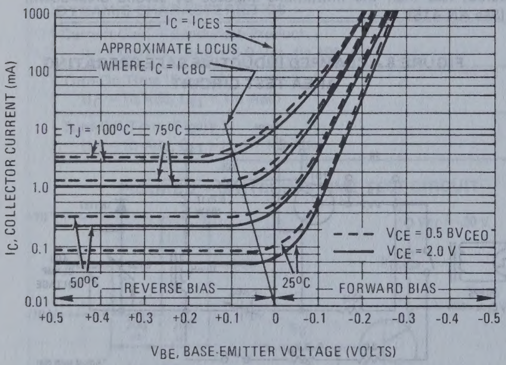
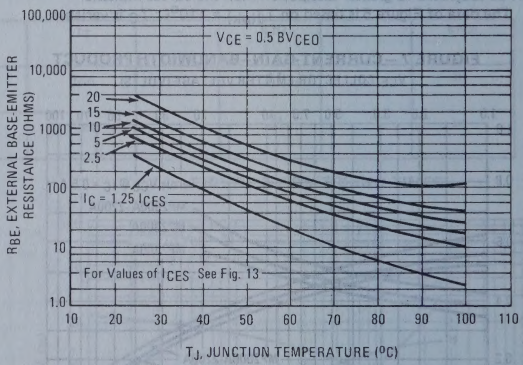
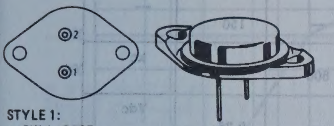


FIGURE 14 – EFFECTS OF BASE EMITTER RESISTANCE



MP2060 thru **MP2063** (GERMANIUM)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

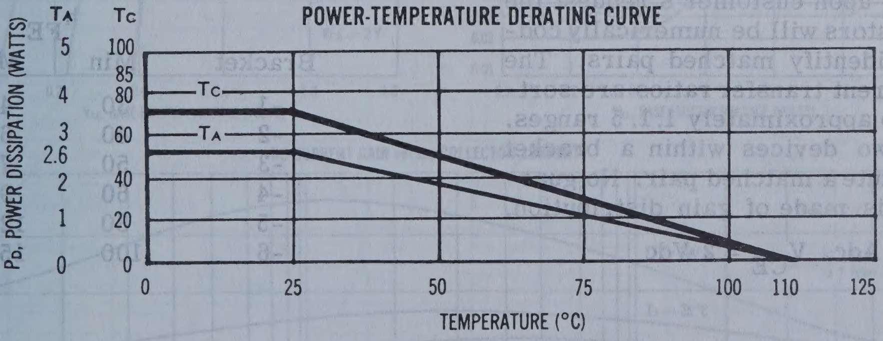
CASE 11

PNP germanium power transistors for audio amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	MP2060	MP2061	MP2062	MP2063	Unit
Collector-Emitter Voltage	V_{CES}	30	45	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	75	90	Vdc
Emitter-Base Voltage	V_{EB}	← 20 →				Vdc
Collector Current (Continuous)	I_C	← 7.0 →				Adc
Peak Collector Current (PW ≦ 5 ms)	I_C	← 15 →				Adc
Base Current (Continuous)	I_B	← 2.0 →				Adc
Storage Temperature	T_{stg}	← -65 to +110 →				^oC
Operating Case Temperature	T_C	← -65 to +110 →				^oC
Total Device Dissipation @T_C = 25^{o}C Derate above 25^{o}C	P_D	← 85 → ← 1.0 →				Watts W/^{o}C
Thermal Resistance Junction to Case	θ_{JC}	1.0				^{o}C/W
Thermal Resistance Case to Ambient	θ_{CA}	32.7				^{o}C/W

POWER-TEMPERATURE DERATING CURVE



MP2060 thru MP2063 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
DC Forward Current Gain (Note 1) (I_C = 3 Adc, V_{CE} = 2 Vdc)		h_{FE}	30	—	150	—
Current Gain-Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 12 Vdc)		f_T	—	600	—	kc
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	—	—	0.70	Vdc
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2 Vdc)		g_{FE}	3.0	—	—	mhos
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	MP2060 MP2061 MP2062 MP2063	BV_{CES}*	30 45 60 75	— — — —	— — — —	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 500 mAdc)	MP2060 MP2061 MP2062 MP2063	$V_{CEO(sus)}$*	25 35 40 60	— — — —	— — — —	Vdc
Collector-Base Breakdown Voltage (I_C = 20 mAdc)	MP2060 MP2061 MP2062 MP2063	BV_{CBO}	40 60 75 90	— — — —	— — — —	Vdc
Collector-Base Cutoff Current (V_{CB} = 2 Vdc) (V_{CB} = 25 Vdc) (V_{CB} = 35 Vdc) (V_{CB} = 40 Vdc) (V_{CB} = 60 Vdc)	 MP2060 MP2061 MP2062 MP2063	I_{CBO}	— — — — —	— — — — —	0.060 1.0 1.0 1.0 1.0	mAdc
Collector-Emitter Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C) (V_{CE} = 45 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C) (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C) (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2060 MP2061 MP2062 MP2063	I_{CEX}	— — — —	— — — —	10 10 10 10	mAdc
Emitter-Base Cutoff Current (V_{BE} = 20 Vdc)		I_{EBO}	—	—	1.0	mAdc
Input Impedance (I_C = -500 mAdc, V_{CE} = -12 Vdc, i_b = 1 mAdc, f = 1 kHz)		h_{ie}	—	25	—	ohms
Distortion (I_C = -500 mAdc, V_{CE} = -12 Vdc, R_S = 30 ohms, R_L = 25 ohms, R_E (unbypassed) = 0.33 ohm, P_{out} = 2 watts)		η	—	3.0	—	%

*Sweep Test: 1/2 sine wave, 60 Hz

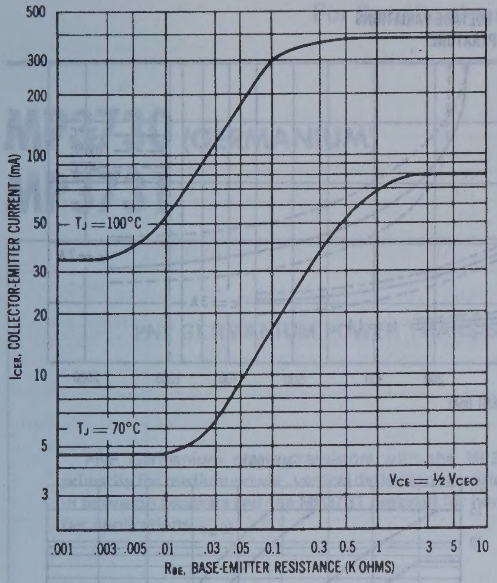
NOTE: upon customer's request the transistors will be numerically coded to identify matched pairs. The dc current transfer ratios are sorted into approximately 1:1.5 ranges. Any two devices within a bracket constitute a matched pair. No guarantee is made of gain distribution.

I_C = 3 Adc, V_{CE} = 2 Vdc

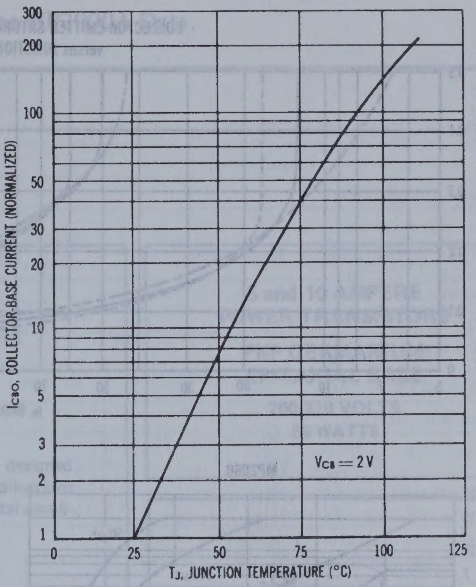
	h_{FE}	
Bracket	Min	Max
-1	30	45
-2	40	60
-3	50	75
-4	60	90
-5	80	120
-6	100	150

MP2060 thru MP2063 (continued)

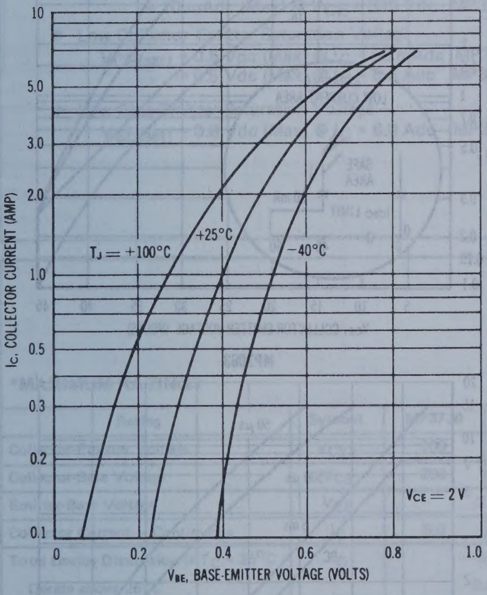
COLLECTOR-EMITTER CURRENT versus BASE-EMITTER RESISTANCE



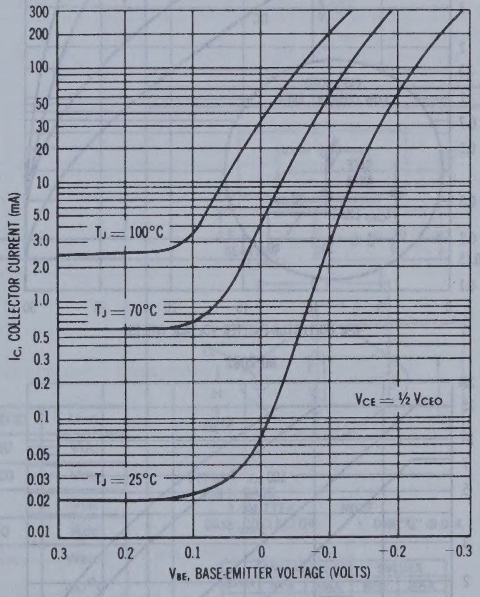
NORMALIZED COLLECTOR-BASE CURRENT



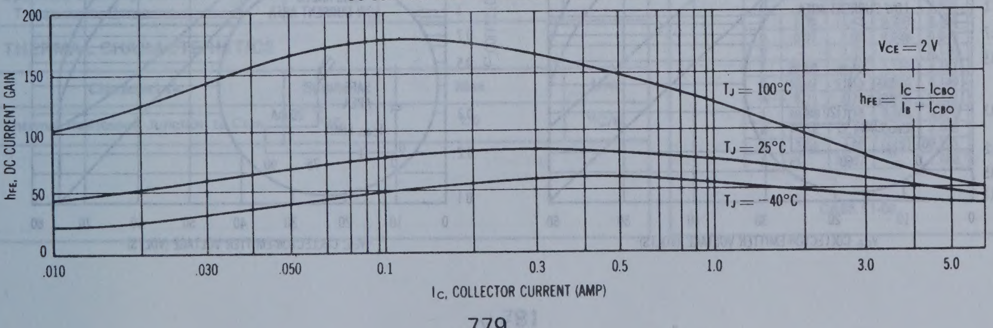
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

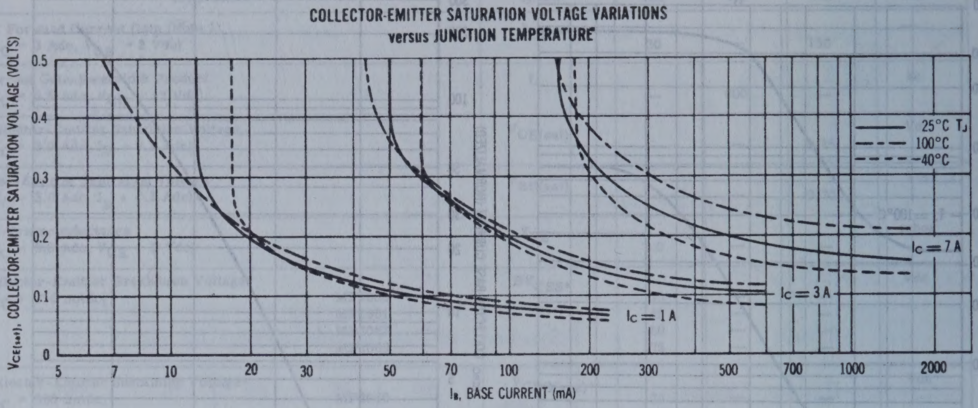


COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

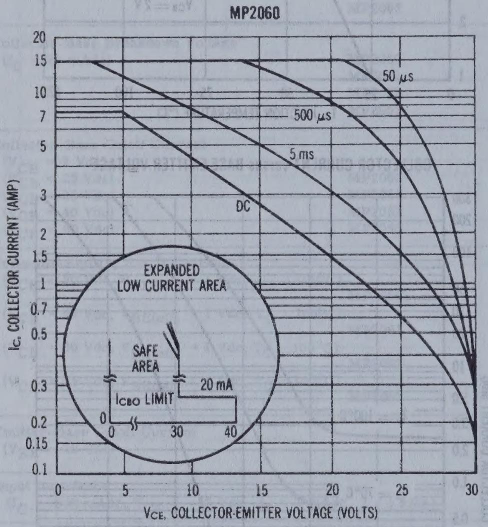


DC CURRENT GAIN versus COLLECTOR CURRENT

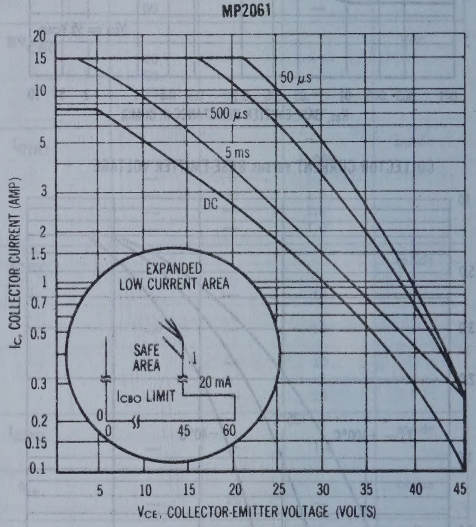




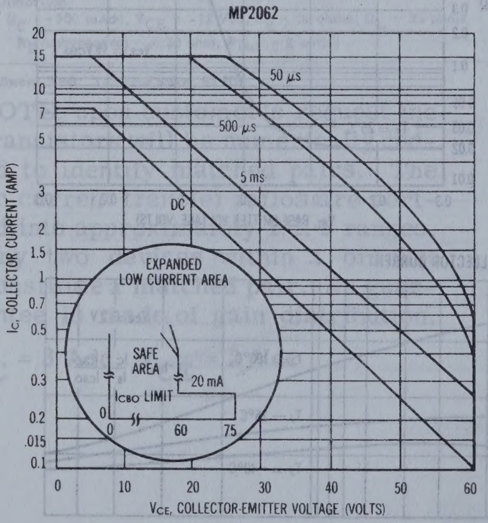
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS versus JUNCTION TEMPERATURE



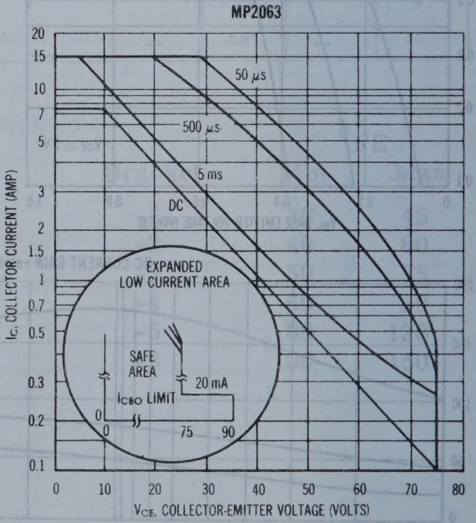
MP2060



MP2061



MP2062



MP2063

MP2100A, MP2200A, MP2300A, MP2400A (GERMANIUM)

For Specifications, See MP2000A Data.

MP3730 (GERMANIUM)
MP3731

5 and 10 AMPERE POWER TRANSISTORS

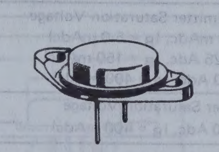
PNP GERMANIUM EPITAXIAL BASE

200-320 VOLTS
56 WATTS

PNP GERMANIUM POWER TRANSISTORS

PNP Germanium power transistors with the MP3730 designed primarily for medium-power, vertical deflection amplifier applications in television receivers and the MP3731 designed for horizontal amplifier applications.

- Low Collector Cutoff Current –
  I_{CES} = 5.0 mAdc (Max) @ V_{CE} = 200 Vdc MP3730
  = 10 mAdc (Max) @ V_{CE} = 320 Vdc MP3731
- Low Collector Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 50 mAdc MP3730
  = 0.5 Vdc (Max) @ I_C = 6.0 Adc MP3731
- Low Base-Emitter Saturation Voltage –
  $V_{BE(sat)}$ = 0.8 Vdc (Max) @ I_C = 6.0 Adc MP3731

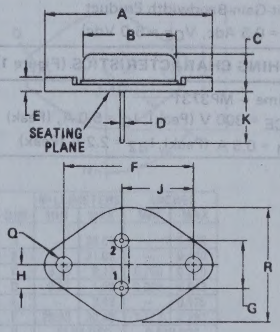


***MAXIMUM RATINGS**

Rating	Symbol	MP3730	MP3731	Unit
Collector-Emitter Voltage	V_{CES}	200	320	Vdc
Collector-Base Voltage	V_{CB}	200	320	Vdc
Emitter-Base Voltage	V_{EB}	2.0		Vdc
Collector Current – Continuous	I_C	5.0	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	56 0.67		Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

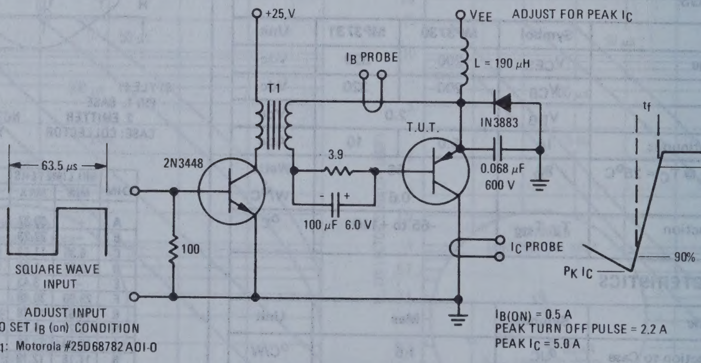
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	39.37	–	1.550
B	–	22.23	–	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 200 Vdc, V_{BE} = 0)	MP3730		–	5.0	
(V_{CE} = 320 Vdc, V_{BE} = 0)	MP3731		–	10	
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	–	0.4	mAdc
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 0.5 Vdc, I_C = 0)	MP3730		–	50	
(V_{BE} = 2.0 Vdc, I_C = 0)	MP3731		–	50	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 4.0 Vdc)	MP3730		10	200	
(I_C = 2.25 Adc, V_{CE} = 4.0 Vdc)	MP3730		15	–	
(I_C = 6.0 Adc, V_{CE} = 3.0 Vdc)	MP3731		15		
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	MP3730		–	0.5	
(I_C = 2.25 Adc, I_B = 150 mAdc)	MP3730		–	0.75	
(I_C = 6.0 Adc, I_B = 400 mAdc)	MP3731		–	0.5	
Base-Emitter Saturation Voltage (I_C = 6.0 Adc, I_B = 400 mAdc)	MP3731	$V_{BE(sat)}$	–	0.8	Vdc
Base-Emitter On Voltage (I_C = 0.5 mAdc, V_{CE} = 4.0 Vdc)	MP3730	$V_{BE(on)}$	–	0.6	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)		f_T	1.0	–	MHz
SWITCHING CHARACTERISTICS (Figure 1)					
Fall Time – MP3731 (V_{CE} = 300 V (Peak), I_C = 5.0 A, (Peak) I_{B1} = 0.5 A (Peak), I_{B2} = 2.2 A (Peak)		t_f	–	2.0	μs

FIGURE 1 – SWITCHING TIME TEST CIRCUIT


+25,V
V_EE
ADJUST FOR PEAK I_C
I_B PROBE
L = 190 μH
T1
T.U.T.
IN3883
63.5 μs
2N3448
3.9
0.068 μF
600 V
100 μF 6.0 V
100
I_C PROBE
t_f
10%
90%
P_K I_C
SQUARE WAVE
INPUT
ADJUST INPUT
TO SET I_B (on) CONDITION
T1: Motorola #25D68782A01-0
I_B(ON) = 0.5 A
PEAK TURN OFF PULSE = 2.2 A
PEAK I_C = 5.0 A

NOTE: If transformer is not readily available, it may be simulated as follows: Material: ¼ inch thick EI stack-laminated soft iron. Center leg ¼ inch by ¼ inch. (No air gap.) Primary: 260 turns No. 30 (AWG) Secondary: 22 turns No. 24 (AWG)

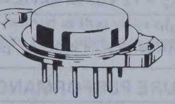
HIGH POWER POSITIVE VOLTAGE REGULATOR

The MPC1000 is a positive voltage regulator designed to deliver load current to 10 Adc. Output current capability can be increased further through use of one or more external pass transistors. The MPC1000 is specified for operation over the junction temperature range (-55 to +175°C)

- 100 Watt Power Capability
- Output Voltage Adjustable – 2 to 35 Vdc
- Output Current to 10 Adc Without External Pass Transistors
- 0.1% Line and Load Regulation
- Temperature Stability 0.005%/°C Typ
- Adjustable Overload Protection

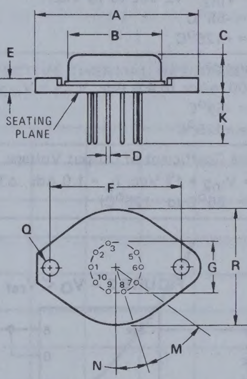
VOLTAGE REGULATOR

HIGH-CURRENT
10 AMPERE



MAXIMUM RATINGS (T_C = +25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Pulse Voltage from V_{in2} to V_{EE} (50 ms)	$V_{in2(p)}$	50	V_{peak}
Continuous Voltage from V_{in2} to V_{EE}	V_{in2}	40	Vdc
Input-Output Voltage Differential	V_{in1}-V_O	60	Vdc
Output Current	I_L	10	Adc
Current from V_{ref}	I_{ref}	15	mA
Internal Power Dissipation @ T_C = 25°C Derate above T_C = 25°C	P_D $1/R_{\theta JC}$	100 0.667	Watts W/°C
Operating Junction Temperature Range	T_J	-55 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C
Operating Case Temperature Range	T_C	-55 to +150	°C


A
B
C
E
K
SEATING PLANE
D
F
Q
G
R
M
N
1
2
3
5
6
7
8
9
10

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	38.61	–	1.520
B	–	21.03	–	0.830
C	6.35	8.13	0.250	0.320
D	0.97	1.09	0.038	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	11.94 BSC		0.470 BSC	
K	7.11	8.13	0.280	0.320
M	36° BSC		36° BSC	
N	18° BSC		18° BSC	
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

NOTE:
1. LEADS WITHIN 0.13 mm (0.005) DIA OF TRUE POSITION AT MAXIMUM MATERIAL CONDITION.

CASE 662-01

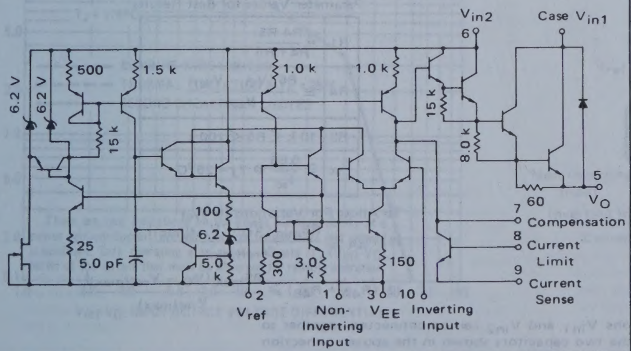
SOCKET/WASHER NOTE:

Mica Insulating Washer: Electronic Essentials Part No. MI-9-1000

Socket: Electronic Essentials
Part No. MS-9-1000
Electronic Essentials, Inc.
49 Bleeker Street
New York, New York 10012

The Case 662-01 pin configuration is compatible with 9-pin miniature vacuum tube sockets.

FIGURE 1 – CIRCUIT SCHEMATIC


V_{in2}
6
Case V_{in1}
6.2 V
6.2 V
500
1.5 k
1.0 k
1.0 k
15 k
15 k
8.0 k
100
6.2
25
5.0 pF
5.0 k
300
3.0 k
150
5
V_O
60
7 Compensation
8 Current Limit
9 Current Sense
2 V_{ref}
1 Non-Inverting Input
3 V_{EE}
10 Inverting Input

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$, $V_{in1} = V_{in2} = 12$ Vdc, $V_{EE} = 0$, $V_O = 5.0$ Vdc, $I_L = 10$ mAdc, unless otherwise noted.)

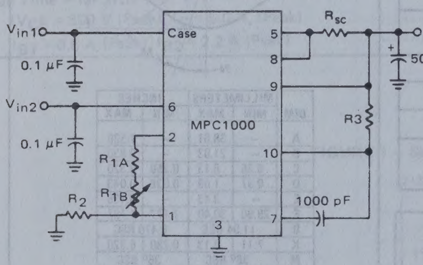
Characteristic	Figure No.	Note	Symbol	Min	Max	Unit
Input Voltage Range	2	1	V_{in2}	9.5	40	Vdc
Output Voltage Range	2	–	V_O	2.0	35	Vdc
Input-Output Voltage Differential ($I_L = 10$ mAdc)	2	2	V_{in1}-V_O V_{in2}-V_O	– –	60 38	Vdc
($I_L = 4.0$ Adc)	2	2	V_{in1}-V_O V_{in2}-V_O	3.0 5.0	– –	
Reference Voltage	2	3	V_{ref}	6.8	7.5	Vdc
Standby Current Drain ($I_L = 0$, $V_{in1} = V_{in2} = 30$ Vdc, $V_O = 5.0$ Vdc)	2	8	I_{IB}	–	5.0	mAdc
Line Regulation ($V_{in1} = V_{in2} = 12$ Vdc to 15 Vdc) ($V_{in1} = V_{in2} = 12$ Vdc to 40 Vdc)	2 2	2,6 2,6	Reg_{in} Reg_{in}	– –	0.1 0.5	$\%V_O$ $\%V_O$
Load Regulation ($I_L = 100$ mAdc to $I_L = 4.0$ Adc, pulsed)	2	2,4,7	Reg_{load}	–	0.1	$\%V_O$

TEMPERATURE PERFORMANCE ($I_L = 10$ mAdc, $V_O = 5.0$ Vdc, $V_{EE} = 0$, unless otherwise noted.)

Characteristic	Figure No.	Note	Symbol	Max	Unit
Line Regulation ($V_{in1} = V_{in2} = 12$ Vdc to 15 Vdc) $T_C = -55^oC$ $T_C = +125^oC$	2	2,6	Reg_{in}	 0.5 0.5	 $\%V_O$ $\%V_O$
Load Regulation ($I_L = 100$ mAdc to 4.0 Adc, $V_{in1} = V_{in2} = 12$ Vdc) $T_C = -55^oC$ $T_C = +125^oC$	2	2,4,7	Reg_{load}	 0.6 0.6	 $\%V_O$ $\%V_O$
Temperature Coefficient of Output Voltage ($V_{in1} = V_{in2} = 12$ Vdc, $I_L = 1.0$ Adc, $\Delta T_C = 180^oC$, $T_C = -55^oC$ to $+125^oC$)	2	2,4,5	T_{CVO}	0.015	$\frac{\%V_O}{^oC}$

TYPICAL CIRCUIT CONNECTIONS

FIGURE 2 – $V_O < V_{ref}$



Parameter Values for Best Results

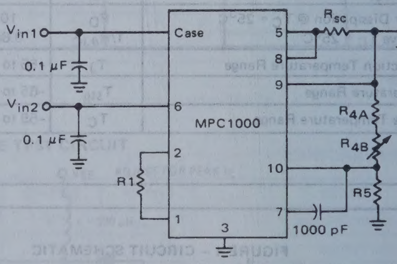
R1	$\cong \frac{R2\,(V_{ref} - V_O)}{V_O}$
R2	$10\text{ k} < R1 + R2 < 100\text{ k}$
R3	$= \left[\frac{R1\ R2}{R1 + R2}\right]$
R_{sc}	$\cong \frac{0.66}{I_{sc}}$ @ $T_J = 25^oC$

To Allow For Variations In V_{ref}

(1) $R_{1A} \leqslant \frac{R_{2min}\,(V_{ref(min)} - V_O)}{V_O}$

(2) $(R_{1A} + R_{1B}) \geqslant \frac{R_{2max}\,(V_{ref(max)} - V_O)}{V_O}$

FIGURE 3 – $V_O > V_{ref}$



Parameter Values for Best Results

R1	$= \frac{R4\ R5}{R4 + R5}$
R4	$\cong \frac{R5\,(V_O - V_{ref})}{V_{ref}}$
R5	$10\text{ k} < R5 < 100\text{ k}$
R_{sc}	$\cong \frac{0.66}{I_{sc}}$ @ $T_J = 25^oC$

To Allow For Variations In V_{ref}

(1) $R_{4A} \leqslant \frac{R5_{min}\,(V_O - V_{ref(min)})}{V_{ref(min)}}$

(2) $(R_{4A} + R_{4B}) \geqslant \frac{R5_{max}\,(V_O - V_{ref(max)})}{V_{ref(max)}}$

In most applications V_{in1} and V_{in2} can be connected together to eliminate one of the two capacitors shown in the above connection diagram. In either situation all capacitors should be as close as possible to the device to minimize lead inductance.

1. "Minimum Input Voltage" is the minimum "total instantaneous input voltage" required to properly bias the internal zener reference diode.
2. Set R_{sc} = 0 (short circuit)
3. V_{ref} voltage is measured from Pin 2 to Pin 3.
4. Pulse test conditions: Load current must be switched from minimum to maximum value at a repetition rate of 10 pps or less with a duty cycle of 1% or less in order to minimize heating effects.
5. The temperature coefficient of output voltage is defined as:

$$T_{CVO} = \frac{\pm(V_{O\ max} - V_{O\ min})\ (100)}{(\Delta T_C)\ (V_O\ @\ T_C = 25^{o}C)}$$

6. The input line regulation is defined as:

$$Reg_{in} = \frac{\pm(V_O\ @\ V_{in\ high} - V_O\ @\ V_{in\ low})}{V_O\ @\ V_{in\ low}} \times 100$$

7. Load regulation is defined as:

$$Reg_{load} = \frac{\pm\ (V_O\ @\ I_{Llow} - V_O\ @\ I_{Lhigh})\ (100)}{(V_O\ @\ I_{Llow})}$$

8. Standby current drain is defined as that value of current measured at Pins 6 and Case when R_L is open circuited.

FIGURE 4 – POWER DERATING

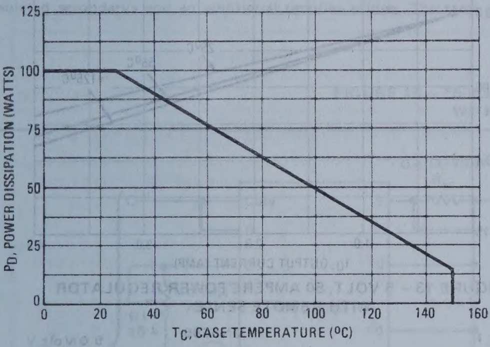


FIGURE 5 – EFFECTIVE THERMAL RESISTANCE

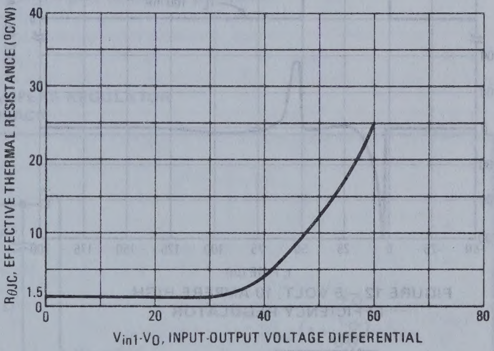
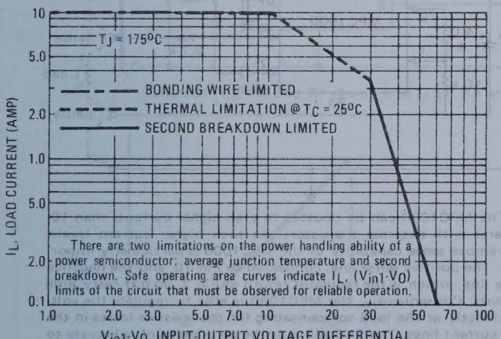
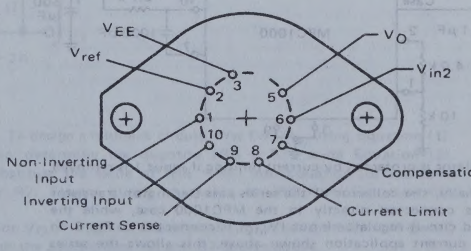


FIGURE 6 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a power semiconductor: average junction temperature and second breakdown. Safe operating area curves indicate I_L, $(V_{in1}-V_O)$ limits of the circuit that must be observed for reliable operation.

FIGURE 7 – PIN CONNECTION – BOTTOM VIEW



NOTE: Case is V_{in1}

FIGURE 8 – LINE REGULATION AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL

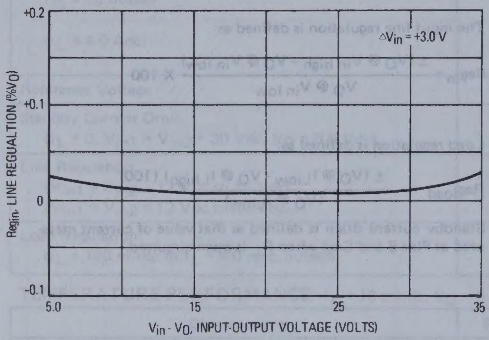


FIGURE 9 – STANDBY CURRENT DRAIN AS A FUNCTION OF INPUT VOLTAGE

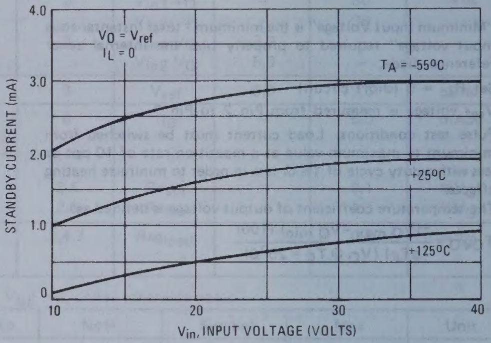


FIGURE 10 – LOAD TRANSIENT RESPONSE

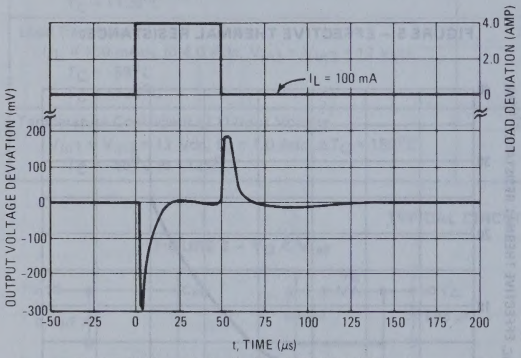


FIGURE 11 – LOAD REGULATION CHARACTERISTICS WITHOUT CURRENT LIMITING

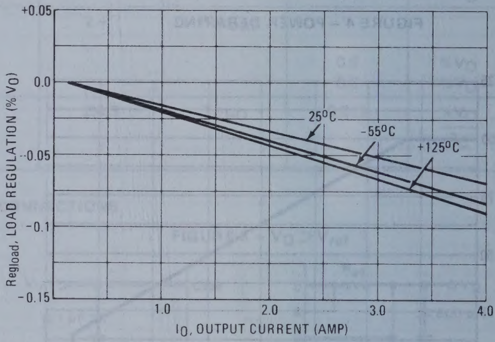
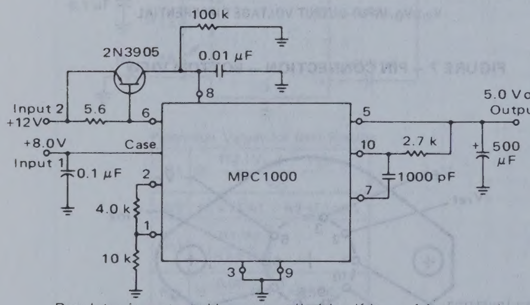


FIGURE 12 – 5 VOLT, 10 AMPERE HIGH EFFICIENCY REGULATOR

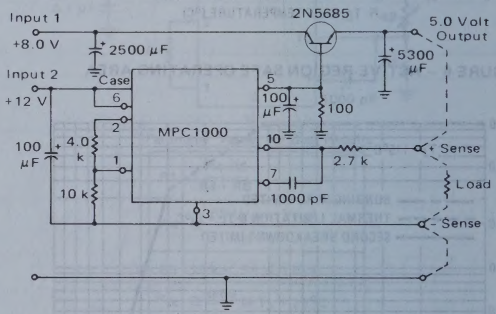


100 k
2N3905
0.01 μF
8
Input 2
+12 V
5.6
6
+8.0 V
Input 1
Case
0.1 μF
2
4.0 k
1
10 k
MPC1000
5
10
7
3
9
2.7 k
1000 pF
5.0 Volt Output
500 μF

Regulator is protected by current limiting if input 1 is removed.

Internally, the collector of the series pass Darlington transistor (V_{in1}) is connected directly to the MPC1000 case, while the integrated circuit regulator input (V_{in2}) is connected to Pin 6. In the high current application shown above, this allows the series pass device to be operated at a lower input-output differential than required by the integrated circuit, thus minimizing power dissipation in the MPC1000. The 2N3905 transistor limits the current from the integrated circuit regulator in case the high current supply to input 1 is removed.

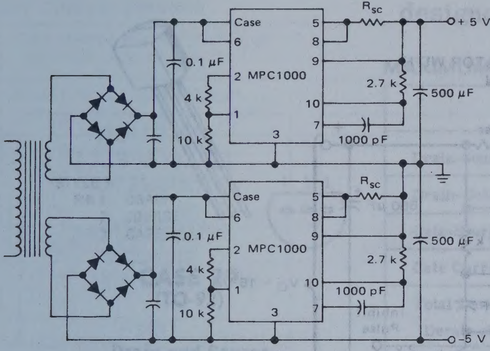
FIGURE 13 – 5 VOLT, 50 AMPERE POWER REGULATOR WITH REMOTE SENSE



Input 1
+8.0 V
2500 μF
2N5685
5.0 Volt Output
5300 μF
Input 2
+12 V
Case
6
5
100 μF
100
2
MPC1000
10
100 μF
4.0 k
1
10 k
2.7 k
7
1000 pF
3
+ Sense
Load
- Sense

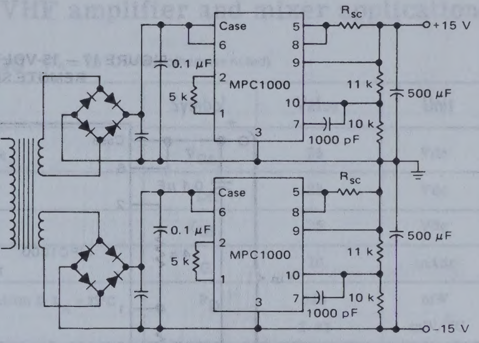
The MPC1000 can be boosted to even higher currents than 10 amperes with external transistors. At such higher current levels, the remote sense capability of the MPC1000 is particularly important. The positive sense line, connected to Pin 10, and the negative sense line, which is the regulator return at Pin 3, do not carry high currents. Consequently, the MPC1000 is able to regulate the voltage directly at the load compensating for the resistive losses in the high current lines. The 2N5685 must be on a heat sink adequate to keep its case temperature below 112°C. This circuit has no short circuit current limiting.

FIGURE 14 – POSITIVE AND NEGATIVE 5-VOLT SUPPLY USING TWO MPC1000's


Case
6
5
8
9
10
7
3
2
1
MPC1000
0.1 µF
4 k
10 k
R_{sc}
+ 5 V
2.7 k
500 µF
1000 pF
–5 V

$$R_{sc} = \frac{0.66}{I_{sc}} \text{ @ } T_J = 25^{\circ}C$$

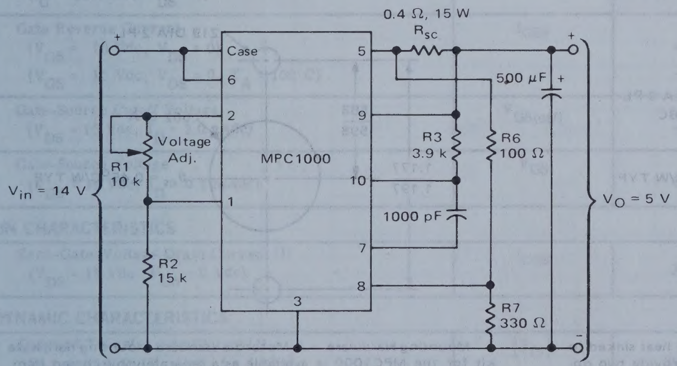
FIGURE 15 – POSITIVE AND NEGATIVE 15 VOLT SUPPLY USING TWO MPC1000's


Case
6
5
8
9
10
7
3
2
1
MPC1000
0.1 µF
5 k
R_{sc}
+15 V
11 k
10 k
500 µF
1000 pF
–15 V

$$R_{sc} \cong \frac{0.66}{I_{sc}} \text{ @ } T_J = 25^{\circ}C$$

Some systems require both positive and negative regulated voltages. This can be accomplished using two MPC1000's as shown in Figures 14 and 15. The circuit requires a line transformer with isolated secondarys and an additional rectifier bridge. The same approach can be expanded to obtain additional positive or negative voltages provided that the isolation is maintained and one common point is used throughout the system.

FIGURE 16 – *5-VOLT, 5 AMPERE REGULATOR WITH FOLDBACK

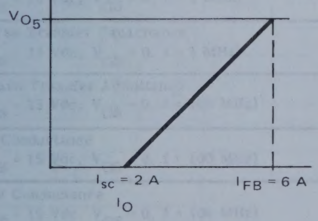

0.4 Ω, 15 W
R_{sc}
Case
6
5
2
9
10
1
7
8
3
MPC1000
Voltage Adj.
R1
10 k
R2
15 k
V_{in} = 14 V
R3
3.9 k
R6
100 Ω
R7
330 Ω
500 µF
1000 pF
+
–
V_O = 5 V

Values of R_{sc}, R6 and R7 shown give I_{FB} = 6A and I_{sc} = 2A.

(1) $R_{sc} = \dfrac{V_O}{I_{sc}\left(1 + \dfrac{V_O}{0.6}\right) - I_{FB}}$

(2) $R6 + R7 \approx V_O/10\text{ mA}$

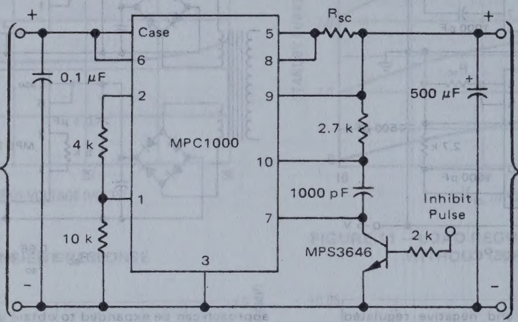
(3) $\dfrac{R7}{R6 + R7} = \dfrac{0.6}{I_{sc}\,R_{sc}}$



To design a foldback circuit, first find R_{sc} using Equation (1), then determine the quantity (R6 + R7) using Equation (2). Substitute the value of (R6 + R7) into Equation (3) and solve for R7. Finally obtain the value for R6 from Equation (2).

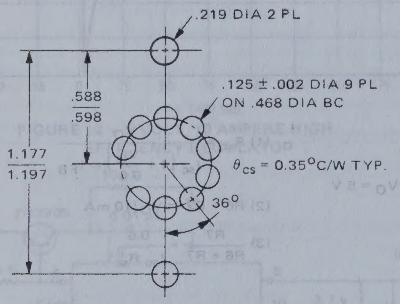
*For $V_O > V_{ref}$ use the typical connections shown in Figure 3 with the additions of R6 and R7 shown above.

FIGURE 17 – 15-VOLT REGULATOR WITH REMOTE SHUTDOWN


+
Case
6
2
MPC1000
1
3
5
8
9
10
7
0.1 μF
4 k
10 k
V_{in}
R_{sc}
2.7 k
500 μF
1000 pF
Inhibit Pulse
2 k
MPS3646
V_O = 15 V
-

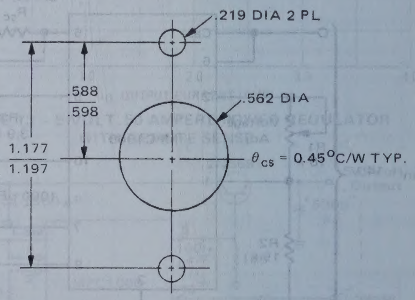
If short circuit protection is not needed, remote shutdown can be accomplished using the internal current limitng transistor by grounding Pin (9), disconnecting Pin (8) and driving Pin (8) with an external 1 mA current source during the shutdown mode.

FIGURE 18 – HEATSINK MOUNTING HOLE PATTERN


.219 DIA 2 PL
.588
.598
.125 ± .002 DIA 9 PL
ON .468 DIA BC
1.177
1.197
θ_{cs} = 0.35°C/W TYP.
36°

Mounting Information – The MPC1000 must be heat sinked to operate at maximum ratings. Figures 18 and 19 provide two options for heat sink mounting hole patterns. The option shown in Figure 18 results in a lower case-to-sink thermal resistance but is more complex than the pattern shown in Figure 19.

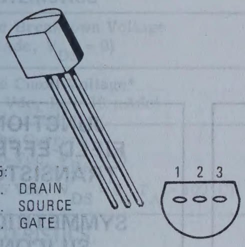
FIGURE 19 – HEATSINK MOUNTING HOLE PATTERN


.219 DIA 2 PL
.588
.598
.562 DIA
1.177
1.197
θ_{cs} = 0.45°C/W TYP.

Mounting Hardware – A Motorola standard mounting hardware kit for the MPC1000 is available as a separately purchased item. This kit is designated by the Motorola part number MK662 and consists of one socket, one mica insulating washer and other associated hardware.

MPF102 (SILICON)

Silicon N-channel junction field-effect transistor designed for VHF amplifier and mixer applications.



STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

CASE 29
(TO-92)

Drain and Source may be interchanged

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature	T_J (1)	125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 µAdc, V_{DS} = 0)	BV_{GSS}	25	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100° C)	I_{GSS}	— —	2.0 2.0	nAdc µAdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 2.0 nAdc)	$V_{GS(off)}$	—	8.0	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 0.2 mAdc)	V_{GS}	0.5	7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc)	I_{DSS}	2.0	20	mAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	$\|y_{fs}\|$	2000	7500	µmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	3.0	pF
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	1600	—	µmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	µmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	µmhos

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

MPF108 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

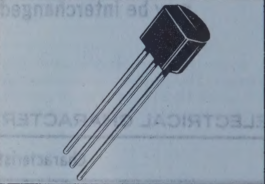
Depletion mode (Type A) transistor designed for VHF amplifier and mixer applications.

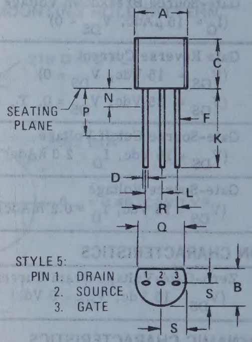
- Devices are Classified and Identified in 2:1 I_{DSS} Ranges
- Low Cross-Modulation and Intermodulation Distortion
- Guaranteed 100 MHz Parameters
- Drain and Source Interchangeable
- Low Transfer and Input Capacitance —
  C_{rss} = 1.2 pF (Typ) @ V_{DS} = 15 Vdc
  C_{iss} = 5.0 pF (Typ) @ V_{DS} = 15 Vdc
- Low Leakage Current
- Unibloc Plastic Encapsulated Package

JUNCTION FIELD-EFFECT TRANSISTOR

SYMMETRICAL SILICON N-CHANNEL

Type A





STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25° C Derate above 25° C	P_D (1)	310 2.82	mW mW/° C
Operating Junction Temperature Range	T_J (1)	-65 to +135	° C
Storage Temperature Range	T_{stg}	-65 to +150	° C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-25	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}{}^*$	0.5	8.0	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)	I_{GSS}	-	1.0	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 100° C)		-	-1.0	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	$I_{DSS}{}^*$	1.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$y_{fs}{}^*$	2000	7500	μmhos
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\lvert y_{fs}\rvert$	1600	-	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{os}\rvert$	-	75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	-	200	μmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	-	800	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	6.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	2.5	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	-	2.5	dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 k ohm, f = 100 MHz)		-	3.0	

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table. When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DSS}	$V_{GS(off)}$	y_{fs}
Orange	1.5 mAdc Min, 3.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Blue	7.0 mAdc Min, 14 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	3000 to 7500 μmhos

MPF109 (SILICON)

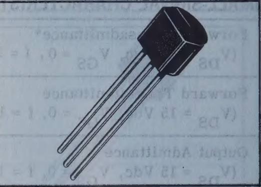
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

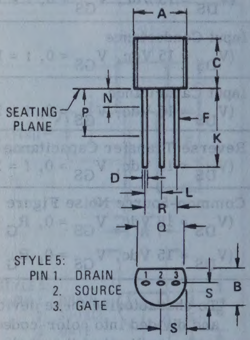
Depletion mode transistor designed for general-purpose audio and switching applications.

- Devices are Classified and Identified in 2:1 Zero-Gate Voltage Drain Current Ranges (2:1 I_{DSS} Ranges)
- Drain and Source Interchangeable
- High AC Input Impedance
- High DC Input Resistance
- Low Transfer and Input Capacitance
- Low Cross-Modulation and Intermodulation Distortion
- Unibloc Plastic Encapsulated Package

JUNCTION FIELD-EFFECT TRANSISTOR

SYMMETRICAL SILICON N-CHANNEL





STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature Range	T_J (1)	-65 to +135	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25°C$, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, $\theta_{JC} = 125°C/W$.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-25	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}$*	0.2	8.0	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)	I_{GSS}	-	-1.0	nAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	0.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}*	800	6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{os}	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	3.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	-	2.5	dB

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DSS}	$V_{GS(off)}$	y_{fs}
White	0.5 mAdc Min, 1.0 mAdc Max	0.2 Vdc Min, 2.0 Vdc Max	800 to 3200 μmhos
Red	0.8 mAdc Min, 1.6 mAdc Max	0.4 Vdc Min, 4.0 Vdc Max	1000 to 4000 μmhos
Orange	1.5 mAdc Min, 3.0 mAdc Max	0.4 Vdc Min, 4.0 Vdc Max	1000 to 4000 μmhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	1.0 Vdc Min, 6.0 Vdc Max	1500 to 5000 μmhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 6.0 Vdc Max	1500 to 5000 μmhos
Blue	7.0 mAdc Min, 14 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	2000 to 6000 μmhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	2000 to 6000 μmhos

MPF 111 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode device designed for general-purpose amplifier and switching applications.

- Low Transfer Capacitance — C_{rss} = 1.5 pF (Typ) @ V_{DS} = 10 Vdc
- Low Input Capacitance — C_{iss} = 4.5 pF (Typ) @ V_{DS} = 10 Vdc
- Unibloc Plastic Encapsulated Package
- Drain and Source Interchangeable

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	-20	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (2)	200 2.0	mW mW/°C
Operating Junction Temperature	T_J (2)	125	°C
Storage Temperature Range	T_{stg}	-65 to +135	°C

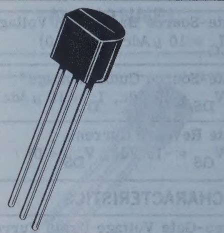
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

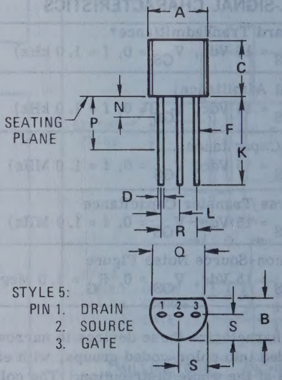
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)	BV_{GSS}	-20	-35	–	Vdc
Gate Reverse Current (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}	–	0.1	100	nAdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	-0.5	-4.0	-10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ① (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	0.5	8.0	20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{fs}\rvert$	500	3000	–	μmhos
Output Admittance ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{os}\rvert$	–	20	–	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.5	–	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	1.5	–	pF

① Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

(2) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR





	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

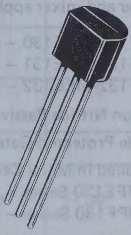
MPF112 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) device designed for VHF amplifier and mixer applications.

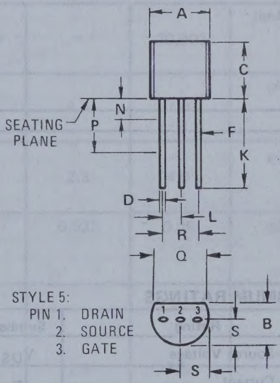
- Low Cross-Modulation Distortion
- Low Transfer Capacitance — C_{rss} = 3.0 pF (Typ) @ V_{DS} = 10 Vdc
- Low Input Capacitance — C_{iss} = 8.0 pF (Typ) @ V_{DS} = 10 Vdc
- Unibloc Plastic Encapsulated Package

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (2)	200 2.0	mW mW/°C
Operating Junction Temperature	T_J (2)	125	°C
Storage Temperature Range	T_{stg}	-65 to +135	°C



STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)	BV_{GSS}	-25	–	–	Vdc
Gate Reverse Current (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}	–	–	100	nAdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	-0.5	–	-10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ① (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	1.0	–	25	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance	$\|y_{fs}\|$				μmhos
(V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz) ①		1000	–	7500	
(V_{DS} = 10 Vdc, V_{GS} = 0, f = 100 MHz)		800	–	–	
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	8.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	3.0	–	pF

① Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.

(2) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

MPF130, MPF131, MPF132 (SILICON)
MFE130, MFE131, MFE132

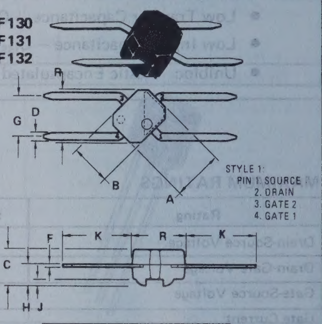
N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type B) dual gate transistors designed for VHF amplifier and mixer applications. These types are specified as follows:

- MPF130/MFE130 – RF Amplifier @ 105 MHz
  MPF131/MFE131 – RF Amplifier @ 60 and 200 MHz
  MPF132/MFE132 – Mixer @ 60 and 200 MHz
- Silicon Nitride Passivation for Excellent Long Term Stability
- Diode Protected Gates
- Supplied in Metal Can or Plastic Packages –
  MFE130 Series – TO-72
  MPF130 Series – Case 262

N-CHANNEL DUAL GATE MOS FIELD – EFFECT TRANSISTORS

MPF130
MPF131
MPF132



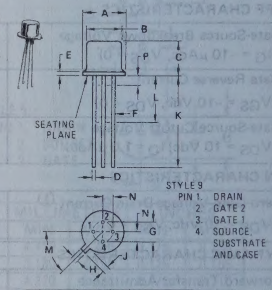
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.95	5.21	0.195	0.205
B	3.94	4.19	0.155	0.165
C	2.67	2.92	0.105	0.115
D	0.64	0.89	0.025	0.035
F	0.20	0.30	0.008	0.012
G	4.06 BSC		0.160 BSC	
H	1.57	1.83	0.062	0.072
J	0.51	0.76	0.020	0.030
K	6.35	7.62	0.250	0.300
R	5.21	5.46	0.205	0.215

CASE 262-02

MAXIMUM RATINGS

Rating	Symbol	Value MPF130 Series	Value MFE130 Series	Unit
Drain-Source Voltage	V_{DS}	25		Vdc
Drain Current	I_D	30		mAdc
Total Power Dissipation @ $T_A = 25^oC$ (Package Limitation)	P_D	350	300	mW
Derate above 25°C		2.33	1.71	mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	-65 to +175	-65 to +200	°C

MFE130
MFE131
MFE132



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS ($T_A = 25^{o}C$ unless otherwise noted) Substrate Connected to Source

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = 10\ \mu Adc$, $V_S = 0$, $V_{G1} = -4.0$ Vdc, $V_{G2} = +4.0$ Vdc)	$V_{(BR)DSX}$	25	–	–	Vdc
Gate 1 – Source Breakdown Voltage ($I_{G1} = \pm 10\ \mu Adc$, $V_{G2S} = 0$)	$V_{(BR)G1SO}$	±7.0	–	±20	Vdc
Gate 2 – Source Breakdown Voltage ($I_{G2} = \pm 10\ \mu Adc$, $V_{G2S} = 0$)	$V_{(BR)G2SO}$	±7.0	–	±20	Vdc
Gate 1 to Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 200\ \mu Adc$)	$V_{G1S(off)}$	–	–	−4.0	Vdc
Gate 2 to Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $V_{G1S} = 0$, $I_D = 200\ \mu Adc$)	$V_{G2S(off)}$	–	–	−4.0	Vdc
Gate 1 Reverse Leakage Current ($V_{G1S} = \pm 6.0$ Vdc, $V_{G2S} = 0$, $V_{DS} = 0$)	I_{G1SS}	–	–	20	nAdc
Gate 2 Reverse Leakage Current ($V_{G2S} = \pm 6.0$ Vdc, $V_{G1S} = 0$, $V_{DS} = 0$)	I_{G2SS}	–	–	20	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{G1S} = 0$, $V_{G2S} = 4.0$ Vdc)	I_{DSS}	3.0	10	30	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transfer Admittance (Gate 1 connected to Drain) ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	y_{fs}	8000	–	20,000	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = I_{DSS}$, f = 1.0 MHz)	C_{iss}	–	4.5	7.0	pF
Output Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = I_{DSS}$, f = 1.0 MHz)	C_{oss}	–	2.5	4.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 6.0$ mAdc, f = 1.0 MHz)	C_{rss}	–	0.023	0.05	pF
Common-Source Noise Figure (Figure 7) ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 6.0$ mAdc, Z_S is optimized for NF)	NF				dB
(f = 105 MHz) MPF/MFE130		–	2.9	5.0	
(f = 60 MHz) MPF/MFE131		–	2.5	5.0	
(f = 200 MHz) MPF/MFE131		–	3.0	5.0	
Common-Source Power Gain (Figure 7) ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 6.0$ mAdc, Z_S is optimized for NF)	G_{ps}				dB
(f = 105 MHz) MPF/MFE130		17	23	–	
(f = 60 MHz) MPF/MFE131		20	27	–	
(f - 200 MHz) MPF/MFE131		17	20	–	
Level of Unwanted Signal for 1.0% Cross Modulation ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, $I_D = 6.0$ mAdc)	–	–	100	–	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 8). ($V_{DS} = 15$ Vdc, $V_{G2S} = 4.0$ Vdc, Local Oscillator Voltage = 925 mVrms)	G_c				dB
(Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz) MPF/MFE132		15	16.5	–	
(Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz) MPF/MFE132		12	14	–	

COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 1 – INPUT ADMITTANCE

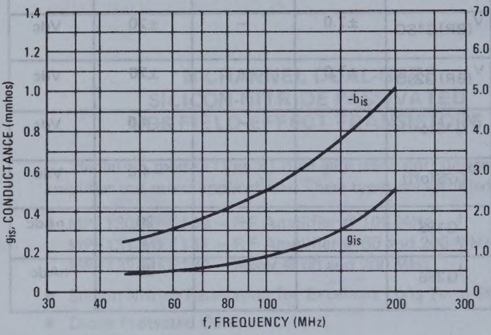


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

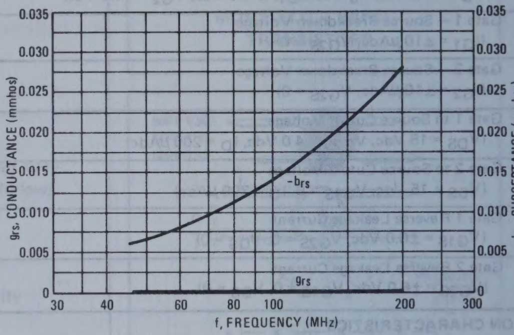


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

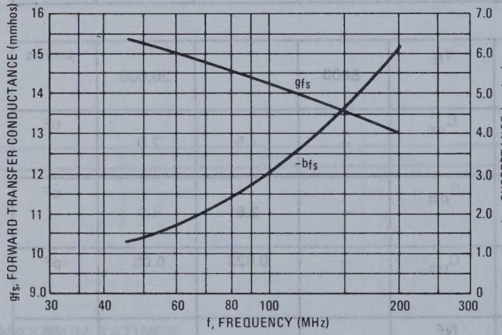


FIGURE 4 – OUTPUT ADMITTANCE

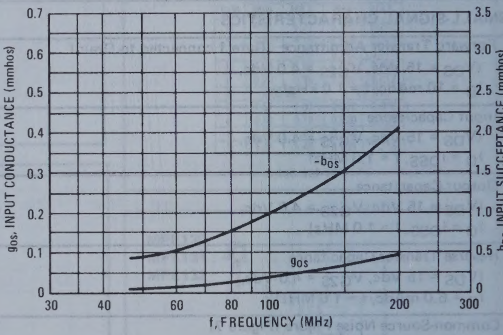


FIGURE 5 – GAIN REDUCTION

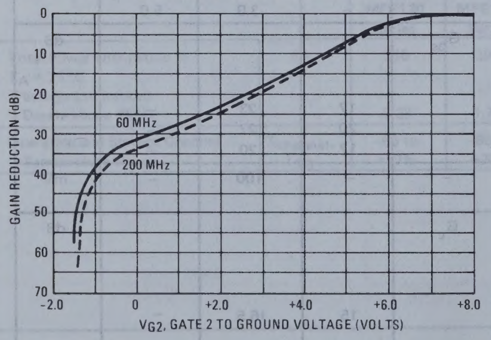


FIGURE 6 – CONVERSION POWER GAIN

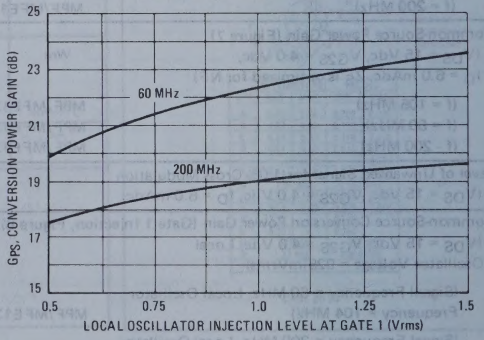
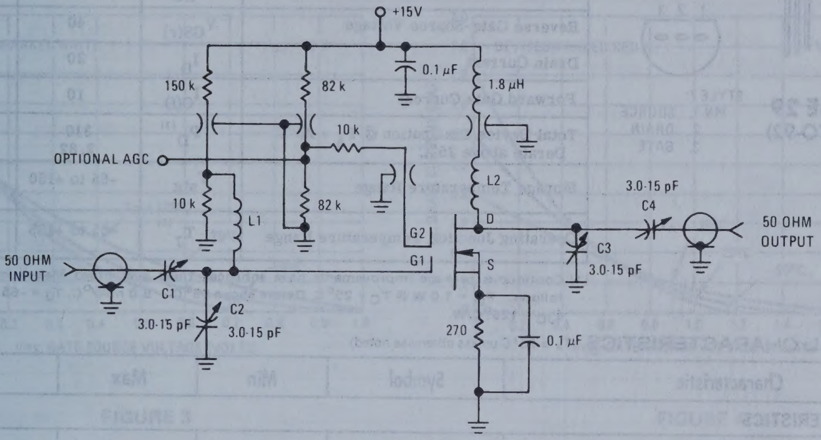


FIGURE 7 – 60, 105 AND 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT

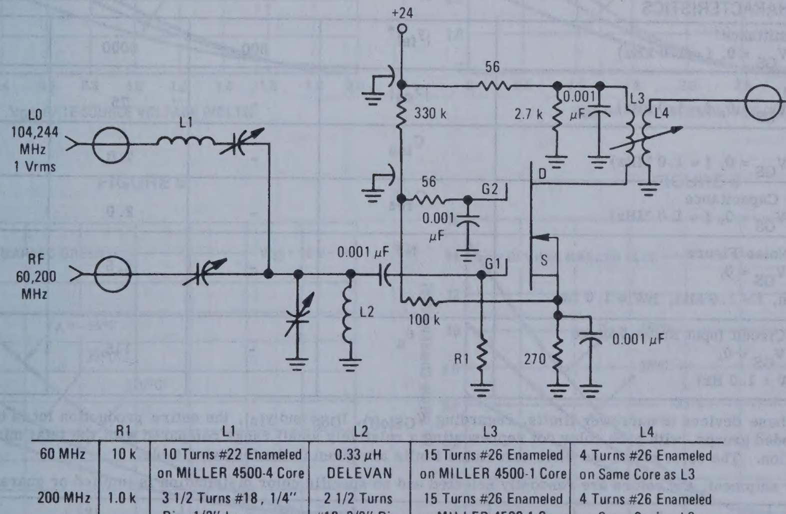

+15V
0.1 µF
1.8 µH
150 k
82 k
10 k
OPTIONAL AGC
10 k
L1
82 k
G2
L2
D
3.0-15 pF
C4
50 OHM
OUTPUT
50 OHM
INPUT
G1
S
C3
3.0-15 pF
C1
C2
3.0-15 pF
3.0-15 pF
270
0.1 µF

	L1	L2
60 MHz	0.33 µH	0.47 µH
105 MHz	#16 AWG, 6 1/2 Turns, 1" Long, 1/4" Dia.	=16 AWG, 5 1/4 Turns, 1" Long, 7/16" Dia.
200 MHz	#16 AWG, 3 1/2 Turns, 0.7" Long, 0.2" Dia.	=16 AWG, 4 1/2 Turns, 0.65" Long, 0.2" Dia.

All Feedthrough Capacitors 1000 pF

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF

FIGURE 8 – 60 AND 200 MHz CONVERSION GAIN TEST CIRCUIT


+24
56
0.001 µF
L3
IF
44 MHz
330 k
2.7 k
L4
LO
104,244
MHz
1 Vrms
L1
D
56
G2
0.001 µF
RF
60,200
MHz
0.001 µF
G1
S
L2
100 k
0.001 µF
R1
270

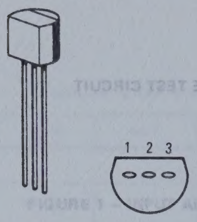
	R1	L1	L2	L3	L4
60 MHz	10 k	10 Turns #22 Enameled on MILLER 4500-4 Core	0.33 µH DELEVAN	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3
200 MHz	1.0 k	3 1/2 Turns #18, 1/4" Dia., 1/2" Long	2 1/2 Turns #18, 3/8" Dia., 1/2" Long	15 Turns #26 Enameled on MILLER 4500-1 Core	4 Turns #26 Enameled on Same Core as L3

All Feedthrough Capacitors 1000 pF.

All Variable Capacitors JOHANSON JMC2951, 3.0-15 pF.

MPF161 (SILICON)

P-channel junction field-effect transistors depletion mode (Type A) designed for general-purpose amplifier applications.



CASE 29
(TO-92)

STYLE 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature Range	T_J (1)	-65 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25°C$, Derate above 25°C – 8.0 mW/°C, $T_J = -65$ to $+150°C$, $\theta_{JC} = 125°C/W$.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10$ μAdc, $V_{DS} = 0$)	$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage* ($V_{DS} = 15$ Vdc, $I_D = 1.0$ μAdc)	$V_{GS(off)}$*	0.2	8.0	Vdc
Gate Reverse Current ($V_{GS} = 30$ Vdc, $V_{DS} = 0$)	I_{GSS}	-	10	nAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}*	0.5	14	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{fs}\|$*	800	6000	μmhos
Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	$\|y_{os}\|$	-	75	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{iss}	-	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 MHz)	C_{rss}	-	2.0	pF
Common-Source Noise Figure ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $R_G = 1.0$ M ohm, f = 1.0 kHz, BW = 1.0 Hz)	NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz, BW = 1.0 Hz)	e_n	-	115	nV/$\sqrt{Hz}$

*To characterize these devices to narrower limits, regarding $V_{GS(off)}$, I_{DSS} and $|y_{fs}|$, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	$V_{GS(off)}$	I_{DSS}	$\|y_{fs}\|$
White	0.2 Vdc Min, 2.0 Vdc Max	0.5 mAdc Min, 1.0 mAdc Max	800 to 3200 μmhos
Red	0.4 Vdc Min, 4.0 Vdc Max	0.8 mAdc Min, 1.6 mAdc Max	1000 to 4000 μmhos
Orange	0.4 Vdc Min, 4.0 Vdc Max	1.5 mAdc Min, 3.0 mAdc Max	1000 to 4000 μmhos
Yellow	1.0 Vdc Min, 6.0 Vdc Max	2.5 mAdc Min, 5.0 mAdc Max	1500 to 5000 μmhos
Green	1.0 Vdc Min, 6.0 Vdc Max	4.0 mAdc Min, 8.0 mAdc Max	1500 to 5000 μmhos
Blue	2.0 Vdc Min, 8.0 Vdc Max	7.0 mAdc Min, 14 mAdc Max	2000 to 6000 μmhos

DRAIN CURRENT versus GATE-SOURCE VOLTAGE

FIGURE 1

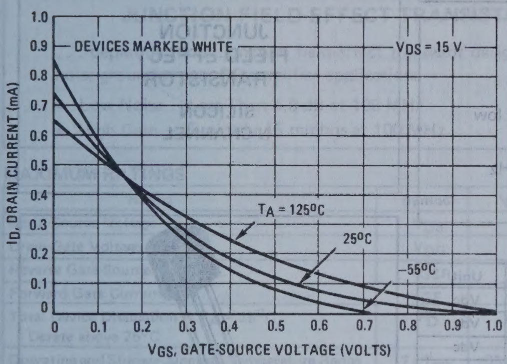


FIGURE 2

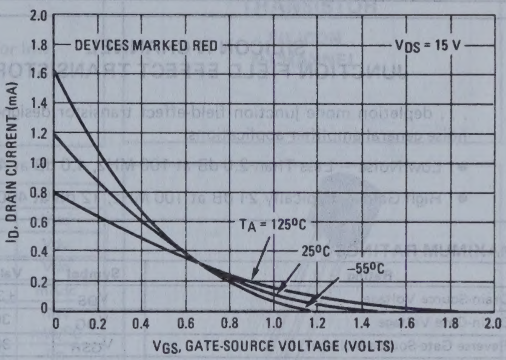


FIGURE 3

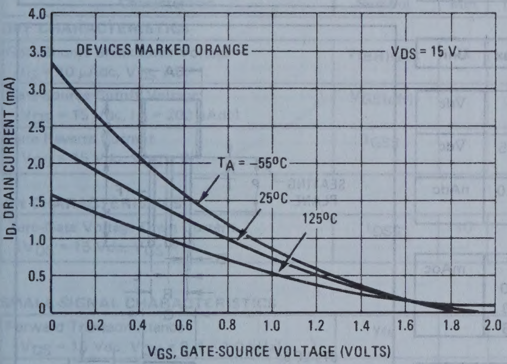


FIGURE 4

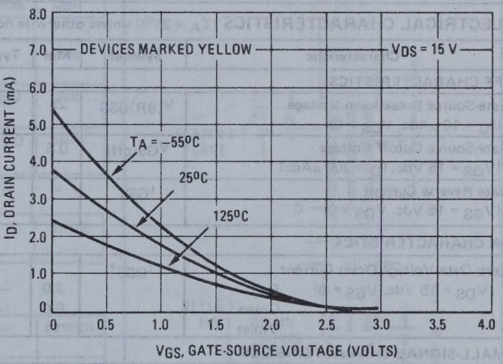


FIGURE 5

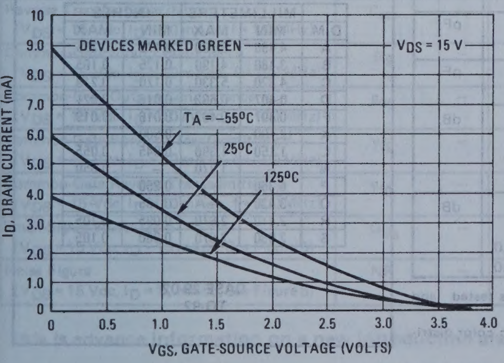
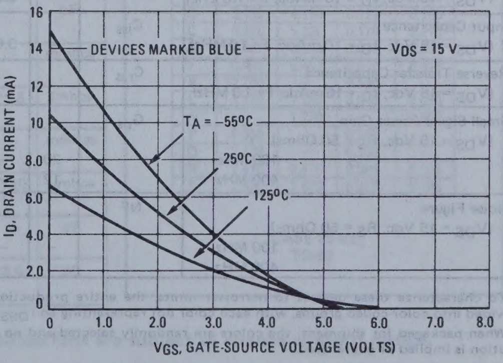


FIGURE 6



MPF256 (SILICON)

Advance Information

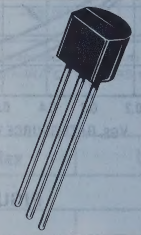
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

. . . depletion mode junction field-effect transistor designed for low noise general amplifier applications.

- Low Noise – Less Than 2.0 dB at 100 MHz, 4.0 dB at 400 MHz.
- High Gain – Typically 21 dB at 100 MHz, 12 dB at 400 MHz.

JUNCTION FIELD-EFFECT TRANSISTOR

SILICON N-CHANNEL



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	±30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

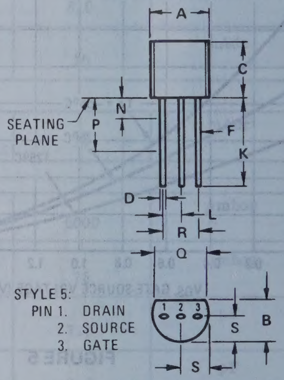
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	–	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 200 μAdc)	$V_{GS(off)}$	0.5	–	7.5	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	–	–	5.0	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*				mAdc
Red		3.0	–	7.0	
Green		6.0	–	13	
Violet		11	–	18	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}	6.0	–	–	mmhos
Output Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	C_{oss}	–	2.0	–	pF
Input Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{iss}	–	3.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	C_{rss}	–	1.2	–	pF
Small-Signal Power Gain (V_{DS} = 15 Vdc, R_S = 50 Ohms)	G_{ps}				dB
100 Mhz		20	–	–	
400 MHz		12	–	–	
Noise Figure (V_{DS} = 15 Vdc, R_S = 50 Ohms)	NF				dB
100 MHz		–	–	2.0	
400 MHz		–	–	4.0	

*To characterize these devices to narrower limits, the entire production lot is tested and divided into color-coded groups, with each color dot representing an I_{DSS} range.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

This is advance information on a new introduction and specifications are subject to change without notice.



STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MPF820 (SILICON)

Advance Information

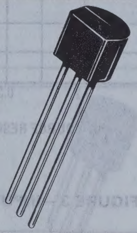
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

. . . depletion mode junction field-effect transistor designed for low noise grounded gate RF amplifier applications.

- Low Noise — Less Than 4.0 dB at 100 MHz
- High Gain — Typically 18 mmhos at 100 MHz

JUNCTION FIELD-EFFECT TRANSISTOR

SILICON N-CHANNEL

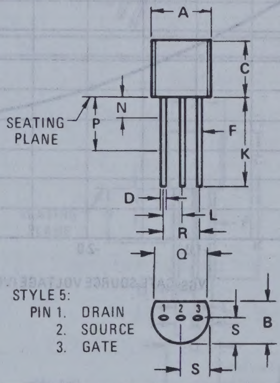


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	–	–	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 200\ \mu Adc$)	$V_{GS(off)}$	–	–	5.0	Vdc
Gate Reverse Current ($V_{GS} = 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	–	–	5.0	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	I_{DSS}	10	–	–	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1.0 kHz)	y_{fs}	–	20	–	mmhos
Output Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 kHz)	C_{oss}	–	3.5	–	pF
Input Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{iss}	–	15	–	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)	C_{rss}	–	3.5	–	pF
Common-Gate Input Conductance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	g_{ig}	–	16	–	mmhos
Common-Gate Output Conductance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	g_{og}	–	–	16	μmhos
Common-Gate Forward Transadmittance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	y_{fg}	–	18	–	mmhos
Common-Gate Reverse Transadmittance ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 100 MHz)	y_{rg}	–	–	130	μmhos
Small-Signal Power Gain ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, See Figure 5)	G_{pg}	–	11	–	dB
Noise Figure ($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, See Figure 5)	NF	–	–	4.0	dB



STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

This is advance information on a new introduction and specifications are subject to change without notice.

FIGURE 1 – NOISE FIGURE

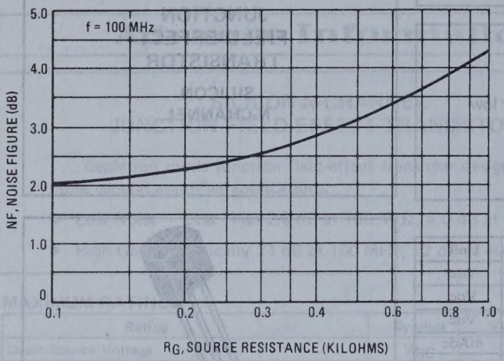


FIGURE 2 – FORWARD TRANSADMITTANCE

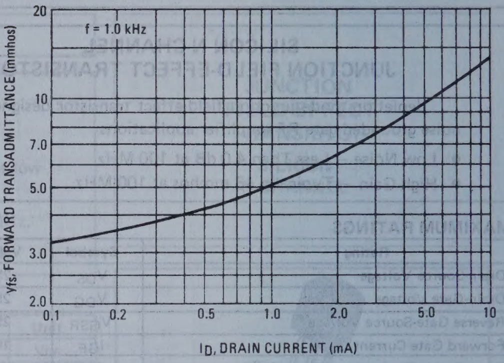


FIGURE 3 – INPUT CAPACITANCE

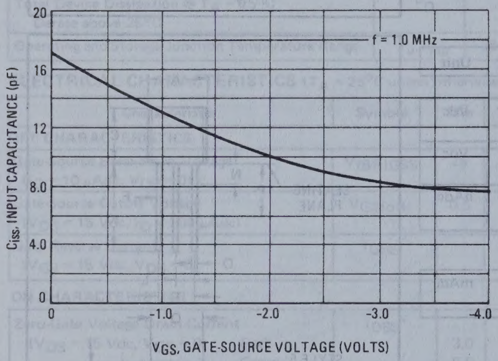


FIGURE 4 – OUTPUT AND REVERSE TRANSFER CAPACITANCE

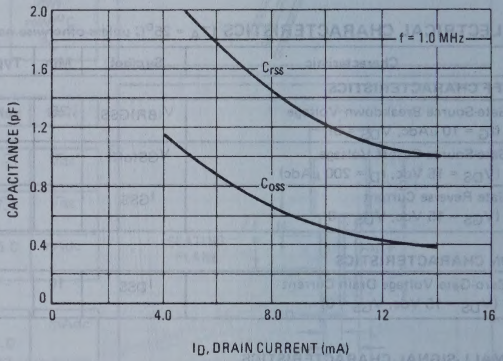
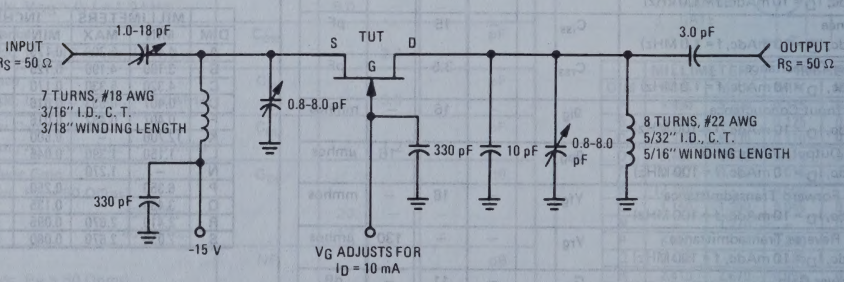


FIGURE 5 – 100 MHz TEST CIRCUIT

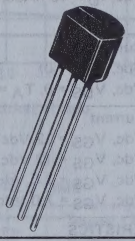

INPUT
RS = 50 Ω
1.0-18 pF
7 TURNS, #18 AWG
3/16" I.D., C.T.
3/18" WINDING LENGTH
330 pF
-15 V
0.8-8.0 pF
TUT
S
D
G
VG ADJUSTS FOR
ID = 10 mA
330 pF
10 pF
0.8-8.0 pF
3.0 pF
OUTPUT
RS = 50 Ω
8 TURNS, #22 AWG
5/32" I.D., C.T.
5/16" WINDING LENGTH

MPF970 (SILICON)
MPF971

SILICON P-CHANNEL JUNCTION FIELD–EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

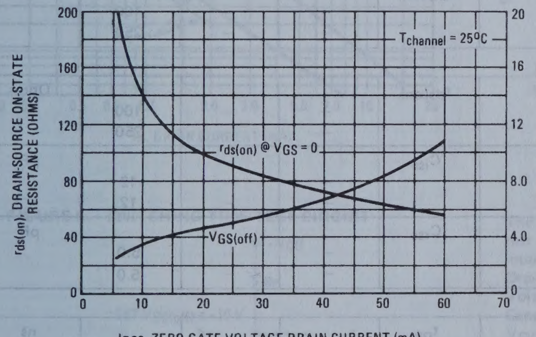
P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +150	^oC
Operating Temperature Range	$T_{channel}$	-65 to +150	^oC

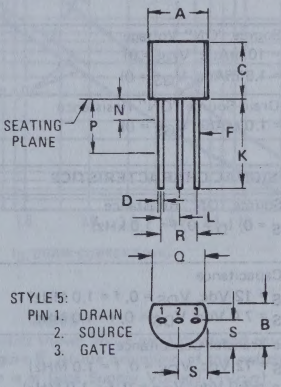
FIGURE 1 – EFFECT OF I_{DSS} ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 1 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 1. This data will be useful in predicting the characteristic variations for a given part number.

For example:
Unknown
$r_{ds(on)}$ and V_{GS} range for an MPF970

The electrical characteristics table indicates that an MPF970 has an I_{DSS} range of 15 to 60 mA. Figure 1 shows $r_{ds(on)}$ = 110 Ohms for I_{DSS} = 15 mA and 56 Ohms for I_{DSS} = 60 mA. The corresponding V_{GS} values are 4.1 volts and 10.8 volts.



STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	30	–	–	Vdc
Gate-Source Cutoff Voltage		$V_{GS(off)}$				Vdc
($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	MPF970		5.0	–	12	
	MPF971		1.0	–	7.0	
Gate Reverse Current		I_{GSS}				
($V_{GS} = 15$ Vdc, $V_{DS} = 0$)			–	–	1.0	nAdc
($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 150^{\circ}C$)			–	–	1.0	μAdc
Drain-Cutoff Current		$I_{D(off)}$				
($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc)	MPF970		–	–	10	nAdc
($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 150^{\circ}C$)	MPF970		–	–	10	μAdc
($V_{DS} = 15$ Vdc, $V_{GS} = 7.0$ Vdc)	MPF971		–	–	10	nAdc
($V_{DS} = 15$ Vdc, $V_{GS} = 7.0$ Vdc, $T_A = 150^{\circ}C$)	MPF971		–	–	10	μAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (1)		I_{DSS}				mAdc
($V_{DS} = 20$ Vdc, $V_{GS} = 0$)	MPF970		15	–	60	
	MPF971		2.0	–	30	
Drain-Source "ON" Voltage		$V_{DS(on)}$				Vdc
($I_D = 10$ mAdc, $V_{GS} = 0$)			–	–	1.5	
($I_D = 1.5$ mAdc, $V_{GS} = 0$)			–	–	1.5	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$				Ohms
($I_D = 1.0$ mAdc, $V_{GS} = 0$)	MPF970		–	–	100	
	MPF971		–	–	250	
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source "ON" Resistance		$r_{ds(on)}$				Ohms
($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	MPF970		–	–	100	
	MPF971		–	–	250	
Input Capacitance		C_{iss}				pF
($V_{GS} = 12$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)	MPF970		–	–	12	
($V_{GS} = 7.0$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)	MPF971		–	–	12	
Reverse Transfer Capacitance		C_{rss}				pF
($V_{GS} = 12$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)	MPF970		–	–	5.0	
($V_{GS} = 7.0$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)	MPF971		–	–	5.0	
SWITCHING CHARACTERISTICS (See Figure 6, $R_K = 0$) (1)						
Turn-On Time		t_{on}				ns
($I_{D(on)} = 10$ mAdc, $V_{GS(off)} = 12$ Vdc)	MPF970		–	3.5	8.0	
($I_{D(on)} = 1.5$ mAdc, $V_{GS(off)} = 7.0$ Vdc)	MPF971		–	5.0	10	
Rise Time		t_r				ns
($I_{D(on)} = 10$ mAdc, $V_{GS(off)} = 12$ Vdc)	MPF970		–	2.0	5.0	
($I_{D(on)} = 1.5$ mAdc, $V_{GS(off)} = 7.0$ Vdc)	MPF971		–	3.0	5.0	
Turn-Off Time		t_{off}				ns
($I_{D(on)} = 10$ mAdc, $V_{GS(off)} = 12$ Vdc)	MPF970		–	13	25	
($I_{D(on)} = 1.5$ mAdc, $V_{GS(off)} = 7.0$ Vdc)	MPF971		–	88	120	
Fall Time		t_f				ns
($I_{D(on)} = 10$ mAdc, $V_{GS(off)} = 12$ Vdc)	MPF970		–	9.0	15	
($I_{D(on)} = 1.5$ mAdc, $V_{GS(off)} = 7.0$ Vdc)	MPF971		–	68	80	

(1) Pulse Test: Pulse Width $\leqslant 100\ \mu s$, Duty Cycle $\leqslant 1.0\%$.

FIGURE 2 – TURN-ON DELAY TIME

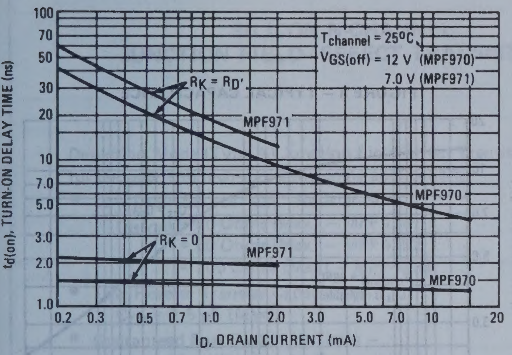


FIGURE 3 – RISE TIME

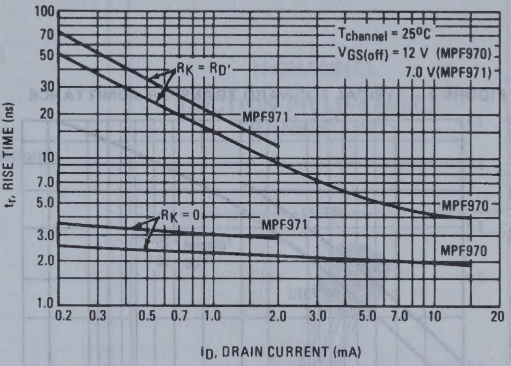


FIGURE 4 – TURN-OFF DELAY TIME

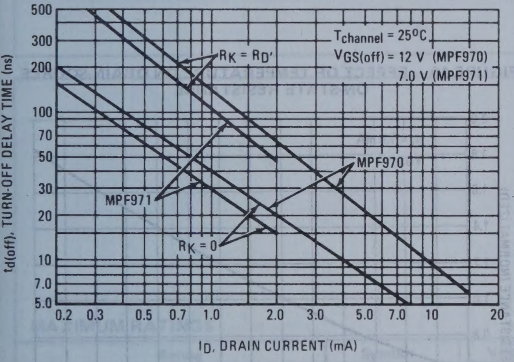


FIGURE 5 – FALL TIME

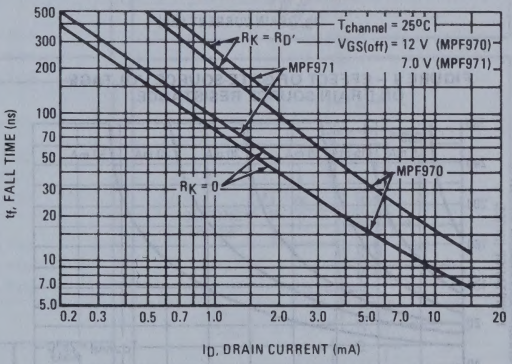
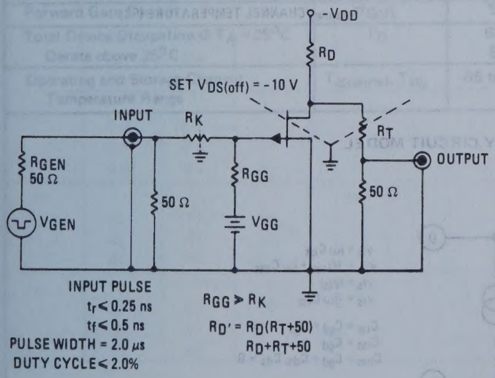


FIGURE 6 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 6. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($+V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to R_D, which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

FIGURE 7 – TYPICAL FORWARD TRANSFER ADMITTANCE

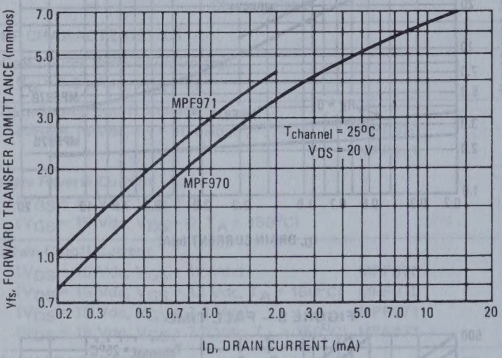


FIGURE 8 – TYPICAL CAPACITANCE

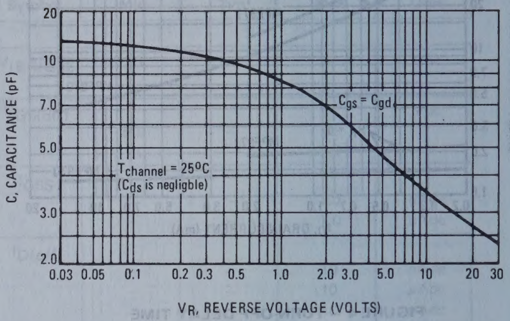


FIGURE 9 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

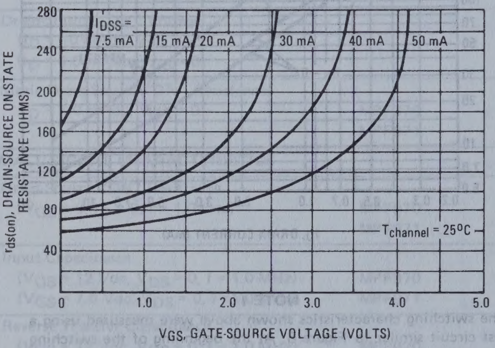


FIGURE 10 – EFFECT OF TEMPERATURE ON DRAIN-SOURCE ON-STATE RESISTANCE

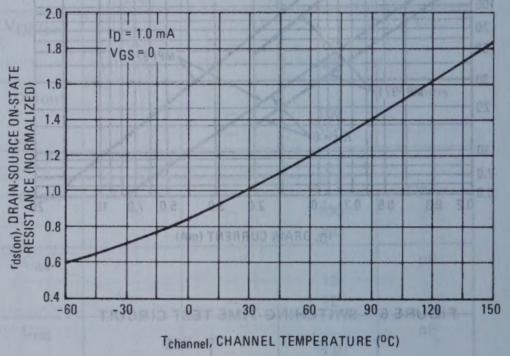
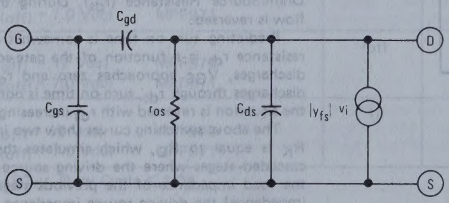


FIGURE 11 – LOW FREQUENCY CIRCUIT MODEL



$y_{is} = j\omega\, C_{iss}$
$y_{os} = 1/r_{oss} + j\omega\, C_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega\, C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds},\ C_{ds} \approx 0$

MPF4391, MPF4392, MPF4393 (SILICON)

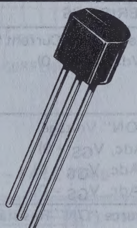
SILICON N-CHANNEL JUNCTION FIELD–EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 30 Ohms (Max) – MPF4391
  = 60 Ohms (Max) – MPF4392
  = 100 Ohms (Max) – MPF4393
- Low Reverse Transfer Capacitance –
  C_{rss} = 3.5 pF (Max)
- Guaranteed Fast Switching Times –
  t_{on} = 15 ns (Max) – All Types
  t_{off} = 20 ns (Max) – MPF4391
  = 35 ns (Max) – MPF4392
  = 55 ns (Max) – MPF4393

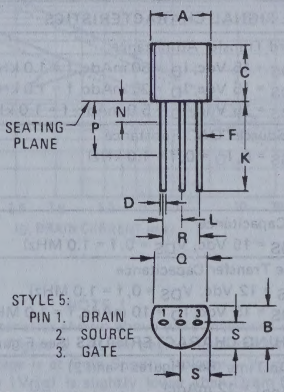
N-CHANNEL

JUNCTION FIELD-EFFECT TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	-65 to +150	°C



STYLE 5:
PIN 1. DRAIN
2. SOURCE
3. GATE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	30	–	–	Vdc
Gate-Source Voltage		V_{GS}				Vdc
($V_{DS} = 15$ Vdc, $I_D = 10$ nAdc)	MPF4391		4.0	–	10	
	MPF4392		2.0	–	5.0	
	MPF4393		0.5	–	3.0	
Gate Reverse Current		I_{GSS}				
($V_{GS} = 15$ Vdc, $V_{DS} = 0$)			–	–	1.0	nAdc
($V_{GS} = 15$ Vdc, $V_{DS} = 0$, $T_A = 100^{\circ}C$)			–	–	0.2	μAdc
Drain-Cutoff Current		$I_{D(off)}$				
($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc)			–	–	1.0	nAdc
($V_{DS} = 15$ Vdc, $V_{GS} = 12$ Vdc, $T_A = 100^{\circ}C$)			–	–	0.1	μAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (1)		I_{DSS}				mAdc
($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	MPF4391		60	–	130	
	MPF4392		25	–	75	
	MPF4393		5.0	–	30	
Drain-Source "ON" Voltage		$V_{DS(on)}$				Vdc
($I_D = 12$ mAdc, $V_{GS} = 0$)	MPF4391		–	–	0.4	
($I_D = 6.0$ mAdc, $V_{GS} = 0$)	MPF4392		–	–	0.4	
($I_D = 3.0$ mAdc, $V_{GS} = 0$)	MPF4393		–	–	0.4	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$				Ohms
($I_D = 1.0$ mAdc, $V_{GS} = 0$)	MPF4391		–	–	30	
	MPF4392		–	–	60	
	MPF4393		–	–	100	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance		y_{fs}				mmhos
($V_{DS} = 15$ Vdc, $I_D = 60$ mAdc, f = 1.0 kHz)	MPF4391		–	20	–	
($V_{DS} = 15$ Vdc, $I_D = 25$ mAdc, f = 1.0 kHz)	MPF4392		–	17	–	
($V_{DS} = 15$ Vdc, $I_D = 5.0$ mAdc, f = 1.0 kHz)	MPF4393		–	12	–	
Drain-Source "ON" Resistance		$r_{ds(on)}$				Ohms
($V_{GS} = 0$, $I_D = 0$, f = 1.0 kHz)	MPF4391		–	–	30	
	MPF4392		–	–	60	
	MPF4393		–	–	100	
Input Capacitance ($V_{GS} = 15$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)		C_{iss}	–	6.0	10	pF
Reverse Transfer Capacitance		C_{rss}				pF
($V_{GS} = 12$ Vdc, $V_{DS} = 0$, f = 1.0 MHz)			–	2.5	3.5	
($V_{DS} = 15$ Vdc, $I_D = 10$ mAdc, f = 1.0 MHz)			–	3.2	–	
SWITCHING CHARACTERISTICS (See Figure 5, $R_K = 0$)						
Turn-On Time (See Figures 1 and 2)		t_{on}				ns
($I_{D(on)} = 12$ mAdc)	MPF4391		–	3.0	15	
($I_{D(on)} = 6.0$ mAdc)	MPF4392		–	4.0	15	
($I_{D(on)} = 3.0$ mAdc)	MPF4393		–	6.5	15	
Rise Time (See Figure 2)		t_r				ns
($I_{D(on)} = 12$ mAdc)	MPF4391		–	1.2	5.0	
($I_{D(on)} = 6.0$ mAdc)	MPF4392		–	2.0	5.0	
($I_{D(on)} = 3.0$ mAdc)	MPF4393		–	2.5	5.0	
Turn-Off Time (See Figures 3 and 4)		t_{off}				ns
($V_{GS(off)} = 12$ Vdc)	MPF4391		–	10	20	
($V_{GS(off)} = 7.0$ Vdc)	MPF4392		–	20	35	
($V_{GS(off)} = 5.0$ Vdc)	MPF4393		–	37	55	
Fall Time (See Figure 4)		t_f				ns
($V_{GS(off)} = 12$ Vdc)	MPF4391		–	7.0	15	
($V_{GS(off)} = 7.0$ Vdc)	MPF4392		–	15	20	
($V_{GS(off)} = 5.0$ Vdc)	MPF4393		–	29	35	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON DELAY TIME

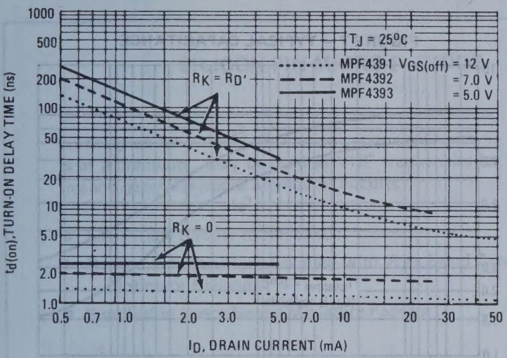


FIGURE 2 – RISE TIME

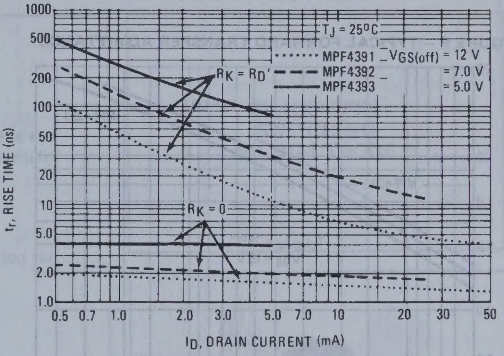


FIGURE 3 – TURN-OFF DELAY TIME

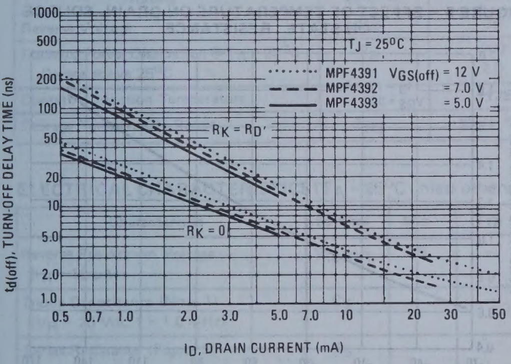


FIGURE 4 – FALL TIME

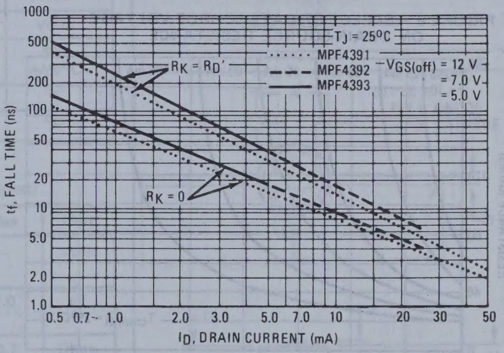
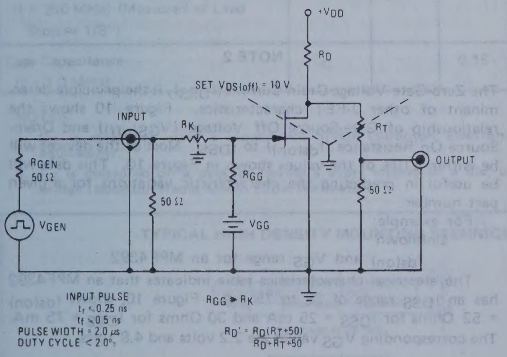


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



NOTE 1

The switching characteristics shown above were measured using a test circuit similar to Figure 5. At the beginning of the switching interval, the gate voltage is at Gate Supply Voltage ($-V_{GG}$). The Drain-Source Voltage (V_{DS}) is slightly lower than Drain Supply Voltage (V_{DD}) due to the voltage divider. Thus Reverse Transfer Capacitance (C_{rss}) or Gate-Drain Capacitance (C_{gd}) is charged to $V_{GG} + V_{DS}$.

During the turn-on interval, Gate-Source Capacitance (C_{gs}) discharges through the series combination of R_{Gen} and R_K. C_{gd} must discharge to $V_{DS(on)}$ through R_G and R_K in series with the parallel combination of effective load impedance (R'_D) and Drain-Source Resistance (r_{ds}). During the turn-off, this charge flow is reversed.

Predicting turn-on time is somewhat difficult as the channel resistance r_{ds} is a function of the gate-source voltage. While C_{gs} discharges, V_{GS} approaches zero and r_{ds} decreases. Since C_{gd} discharges through r_{ds}, turn-on time is non-linear. During turn-off, the situation is reversed with r_{ds} increasing as C_{gd} charges.

The above switching curves show two impedance conditions; 1) R_K is equal to $R_{D'}$ which simulates the switching behavior of cascaded stages where the driving source impedance is normally the load impedance of the previous stage, and 2) $R_K = 0$ (low impedance) the driving source impedance is that of the generator.

FIGURE 6 – TYPICAL FORWARD TRANSFER ADMITTANCE

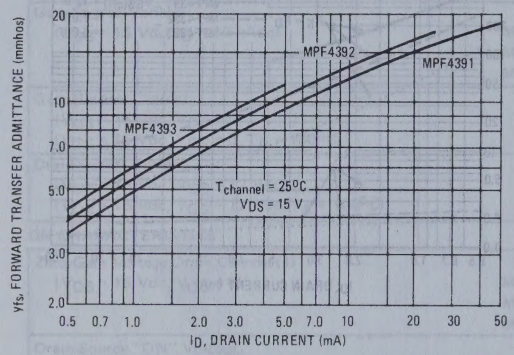


FIGURE 7 – TYPICAL CAPACITANCE

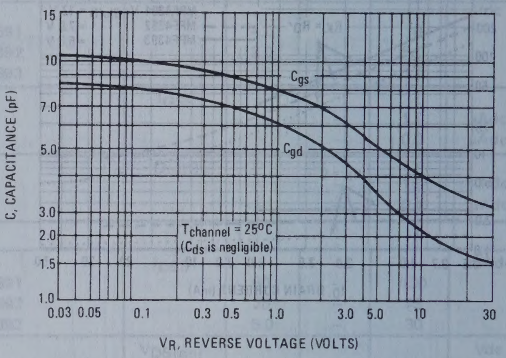


FIGURE 8 – EFFECT OF GATE-SOURCE VOLTAGE ON DRAIN-SOURCE RESISTANCE

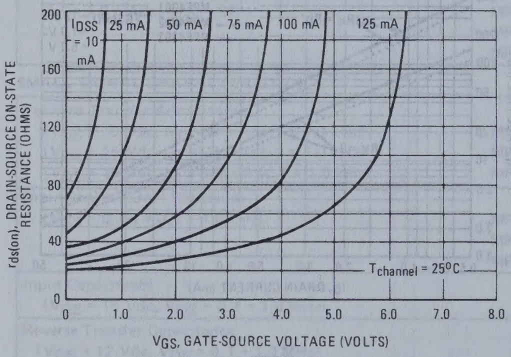


FIGURE 9 – EFFECT OF TEMPERATURE ON DRAIN–SOURCE ON-STATE RESISTANCE

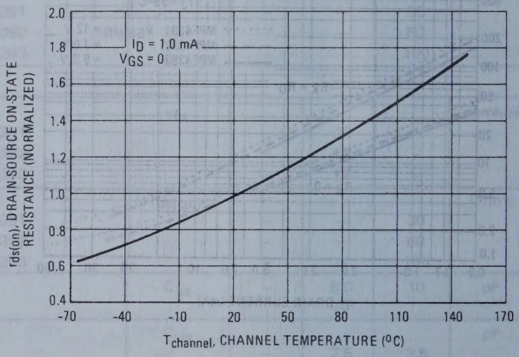
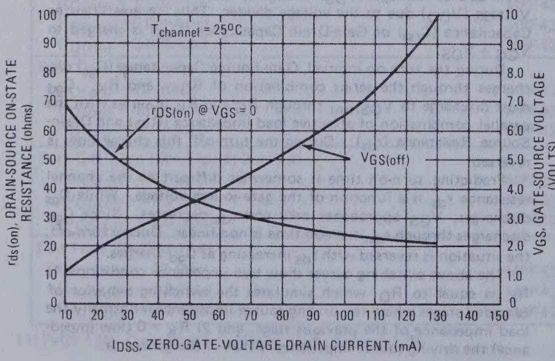


FIGURE 10 – EFFECT OF IDSS ON DRAIN-SOURCE RESISTANCE AND GATE-SOURCE VOLTAGE



NOTE 2

The Zero-Gate-Voltage Drain Current (I_{DSS}), is the principle determinant of other J-FET characteristics. Figure 10 shows the relationship of Gate-Source Off Voltage ($V_{GS(off)}$) and Drain-Source On Resistance ($r_{ds(on)}$) to I_{DSS}. Most of the devices will be within ±10% of the values shown in Figure 10. This data will be useful in predicting the characteristic variations for a given part number.

For example:

Unknown

$r_{ds(on)}$ and V_{GS} range for an MPF4392

The electrical characteristics table indicates that an MPF4392 has an I_{DSS} range of 25 to 75 mA. Figure 10, shows $r_{ds(on)}$ = 52 Ohms for I_{DSS} = 25 mA and 30 Ohms for I_{DSS} = 75 mA. The corresponding V_{GS} values are 2.2 volts and 4.8 volts.

MPI-3401 (SILICON)

SILICON PIN MICRO-I DIODE

. . . designed for industrial/communications applications where space is at a premium. May be used at VHF frequencies for band switching and general-purpose attenuator circuits.

- Electrically Similar to MPN3401
- Rugged PIN Structure Coupled with Wire Bond Construction for Optimum Reliability
- Supplied in Space-Saving Miniature Package

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	200 2.0	mW mW/°C
Operating Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

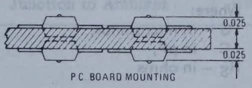
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	35	–	–	Volts
Diode Capacitance (Note 1) (V_R = 20 Vdc, f = 1.0 MHz)	C_T	–	–	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mA)	R_S	–	–	0.7	Ohms
Reverse Leakage Current (V_R = 25 Vdc)	I_R	–	–	0.1	μA
Series Inductance (Note 2) (f = 250 MHz) (Measured at Lead Stop $\approx$ 1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.15	–	pF

NOTES

1. C_T is measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
2. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

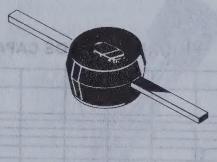
TYPICAL HIGH DENSITY MOUNTING TECHNIQUE



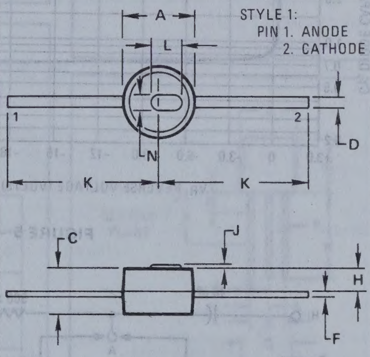
P.C. BOARD MOUNTING

Maximum Solder Temperature:
250°C for 10s

SILICON PIN SWITCHING MICRO-I DIODE



Device marked with white top.



STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
C	1.22	1.47	0.048	0.058
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
L	0.89	1.14	0.035	0.045
N	0.38	0.64	0.015	0.025

Optional Package with Raised Circular Tab Available; Specify Case 166-01.

CASE 166-02

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

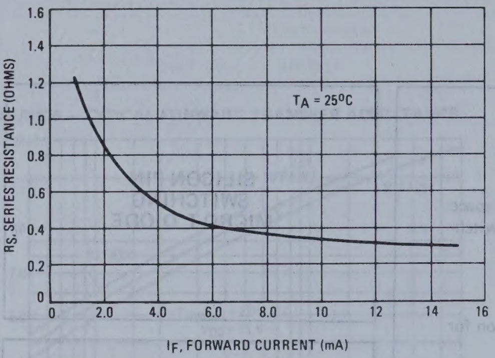


FIGURE 2 – FORWARD VOLTAGE

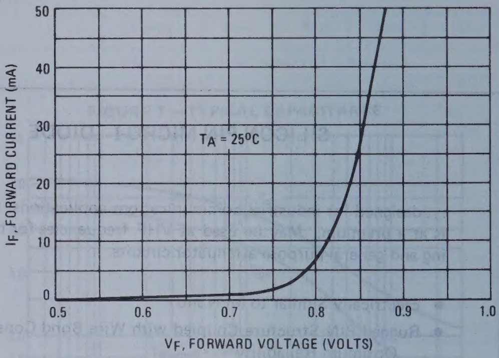


FIGURE 3 – DIODE CAPACITANCE

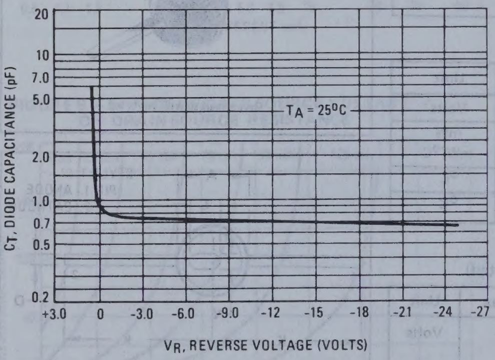


FIGURE 4 – LEAKAGE CURRENT

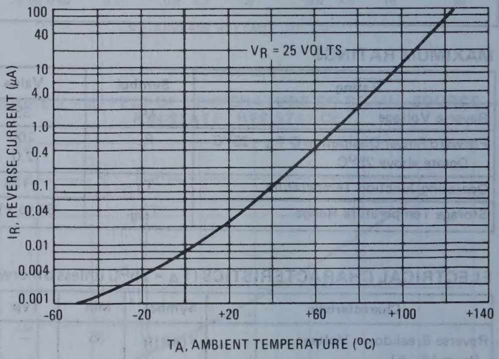
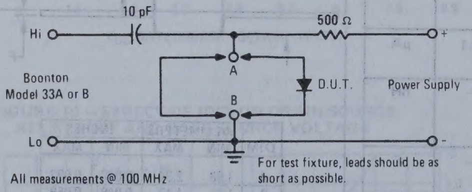


FIGURE 5 – FORWARD SERIES RESISTANCE TEST METHOD


10 pF
500 Ω
Hi
+
A
Boonton
Model 33A or B
D.U.T.
Power Supply
B
Lo
-
For test fixture, leads should be as short as possible.
All measurements @ 100 MHz

To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G – in micromhos,
C – in pF,
R_S – in ohms

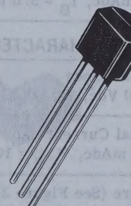
MPM5006 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for television, AM/FM, and general-purpose RF amplifier applications.

- Low Capacitance — C_{ob} = 1.6 pF (Max) @ V_{CB} = 10 Vdc
- High Power Gain — PG = 20 dB (Min) @ f = 100 MHz
- High Collector-Emitter Sustaining Voltage — $BV_{CEO(sus)}$ = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Noise Figure — NF = 5.5 dB (Typ) @ f = 100 MHz
- Forward AGC Characteristic

NPN SILICON RF AMPLIFIER TRANSISTOR

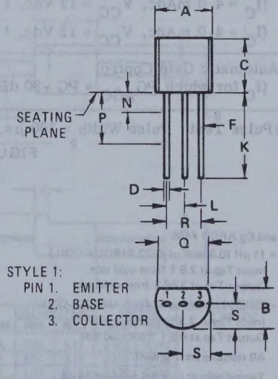


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	100	mAdc
Total Power Dissipation @T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Total Power Dissipation @T_A = 60°C Derate above 60°C	P_D	210 2.81	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 65° C)	I_{CBO}	 - -	 1.0 -	 50 5.0	 nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	70	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	-	-	2.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	-	0.98	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	1.1	1.6	pF
Small-Signal Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	4.0	6.0	-	-
Noise Figure (See Figure 2) (I_C = 4.0 mAdc, V_{CC} = 15 Vdc, R_S = 100 ohms, f = 100 MHz)	NF	-	5.5	-	dB
FUNCTIONAL TESTS					
Power Gain (I_C = 4.0 mAdc, V_{CC} = 12 Vdc, f = 455 kHz) (I_C = 4.0 mAdc, V_{CC} = 12 Vdc, f = 10.7 MHz) (Figure 1) (I_C = 4.0 mAdc, V_{CC} = 12 Vdc, f = 100 MHz) (Figure 2)	PG	 35 28 20	 - - 26	 - - -	dB
Automatic Gain Control (I_C for which PG_{AGC} = PG -30 dB) (Figure 2)	AGC	6.0	9.0	12	mA

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 — 10.7 MHz UNNEUTRALIZED AMPLIFIER TEST CIRCUIT

C_1 and C_2 ARCO #465

L_1 = 11 μH (0.9 inch of #632 AIRDUX COIL)
Input Tap at 2.9 T from cold side
Output Tap at 3.66 T from cold side

L_2 = 1.1 μH (1.5 inches of #608 AIRDUX COIL)
Input Tap at 2.3 T from cold side
Output Tap at 0.5 T from cold side

All resistors are 1/2 Watt.

Typical gain at I_C = 4.0 mAdc is 34 dB.

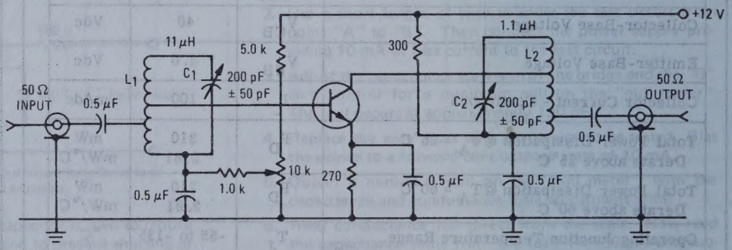
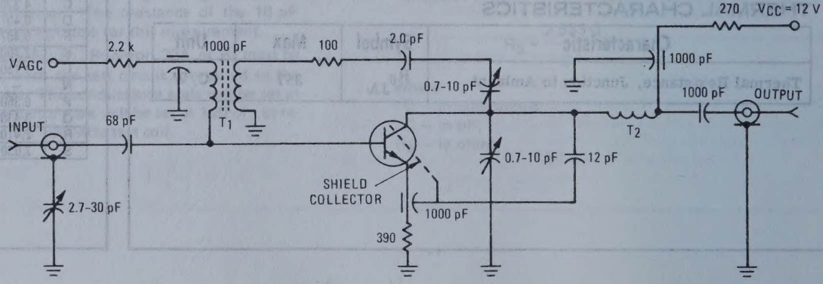

+12 V
11 μH
5.0 k
300
1.1 μH
L1
C1
200 pF
± 50 pF
L2
50 Ω
INPUT
0.5 μF
C2
200 pF
± 50 pF
50 Ω
OUTPUT
0.5 μF
10 k
270
1.0 k
0.5 μF
0.5 μF
0.5 μF

FIGURE 2 — 100 MHz AGC, POWER GAIN AND NOISE FIGURE TEST CIRCUIT

T_1 Ballun Core
1/4″ I.D., 1/8″ Long
5 turns primary
5 turns secondary
#32 Bifilar Wire

T_2 1/4″ I.D.
5″ 2 turns tapped
up 1/2 turn, #16
Buss Wire


270
VCC = 12 V
2.2 k
1000 pF
100
2.0 pF
VAGC
1000 pF
0.7-10 pF
1000 pF
OUTPUT
T1
INPUT
68 pF
T2
0.7-10 pF
12 pF
SHIELD
COLLECTOR
1000 pF
2.7-30 pF
390

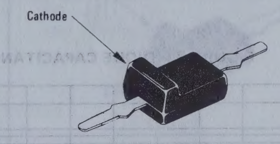
MPN3401 (SILICON)
MPN3402

SILICON PIN DIODE

. . . designed primarily for VHF band switching applications but also suitable for use in general-purpose switching and attenuator circuits. Supplied in an inexpensive low-inductance plastic package for low cost, high-volume consumer and industrial requirements.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Both 1 pF and 2 pF Devices for Design Selectivity
- Very Low Series Resistance at 100 MHz — 0.34 Ohms (Typ) @ I_F = 10 mAdc
- Low Inductance Mini-L Package
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting

SILICON PIN SWITCHING DIODE



MPN3401 — BROWN RIDGE
MPN3402 — BROWN RIDGE, RED BODY STRIPE

MAXIMUM RATINGS

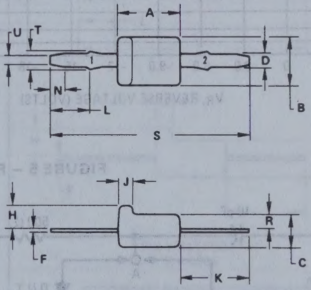
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Volts
Forward Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_F	400 4.0	mW mW/^oC
Junction Temperature	T_J	+125	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10\ \mu A$)	$V_{(BR)R}$	35	—	—	Volts
Diode Capacitance (Note 1) MPN3401 (V_R = 20 Vdc, f = 1.0 MHz) MPN3402	C_T	— —	— —	1.0 2.0	pF
Series Resistance (Figure 5) MPN3401 (I_F = 10 mA) MPN3402	R_S	— —	— —	0.7 0.6	Ohms
Reverse Leakage Current (V_R = 25 Vdc)	I_R	—	—	0.1	µA
Series Inductance (Note 2) (f = 250 MHz) (Measured at Lead Stop ≈ 1/8")	L_S	—	3.0	—	nH
Case Capacitance (f = 1.0 MHz)	C_C	—	0.1	—	pF

NOTES

1. C_T is measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
2. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).



PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

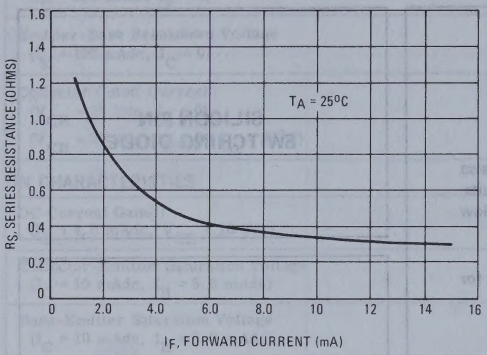


FIGURE 2 – FORWARD VOLTAGE

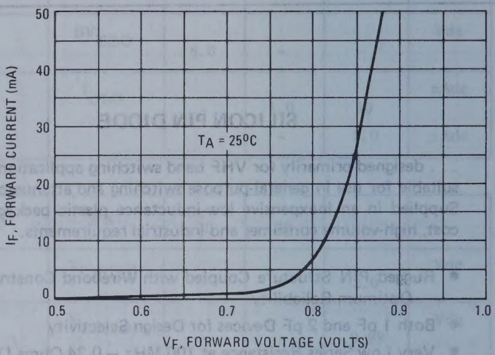


FIGURE 3 – DIODE CAPACITANCE

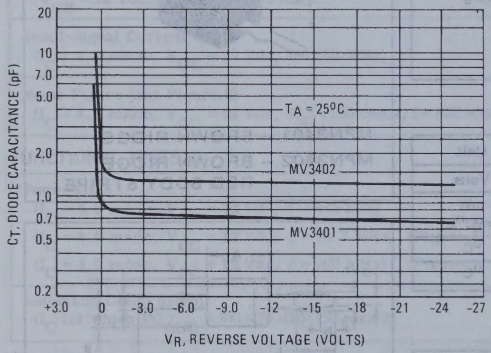


FIGURE 4 – LEAKAGE CURRENT

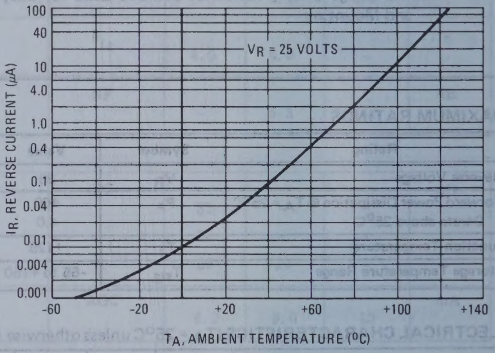
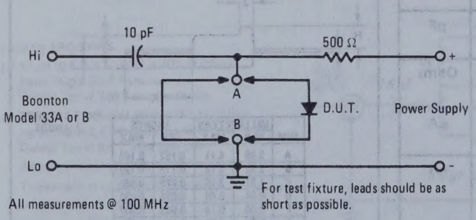


FIGURE 5 – FORWARD SERIES RESISTANCE TEST METHOD



10 pF
500 Ω
Hi
+
A
Boonton
Model 33A or B
D.U.T.
Power Supply
B
Lo
-
For test fixture, leads should be as short as possible.
All measurements @ 100 MHz

To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G – in micromhos,
C – in pF,
R_S – in ohms

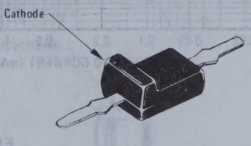
MPN3411 (SILICON)

PIN ATTENUATOR DIODE

. . . designed primarily as a general purpose attenuator diode. Supplied in popular low-inductance, Mini-L plastic package for low cost, high-volume consumer and industrial requirements.

- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Characterization of Forward Resistance @ 5, 20, 50 and 100 MHz for Greater Design Flexibility
- Low Inductance Mini-L Package
- Mini-L Ridge Clearly Identifies Cathode Lead for Easy Handling and Mounting
- Can be used for AGC in T and Pi configurations.

SILICON PIN ATTENUATOR DIODE



MAXIMUM RATINGS

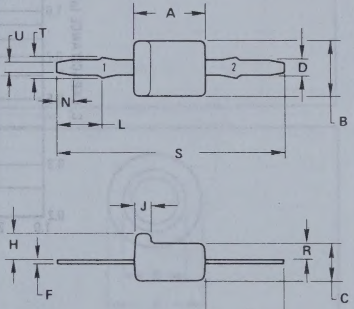
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	25	Volts
Forward Power Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10\ \mu A$)	$V_{(BR)R}$	25	100	–	Volts
Diode Capacitance (Note 1) ($V_R = 20$ Vdc, f = 100 MHz)	C_T	–	–	0.45	pF
Forward Resistance ($I_F = 10$ mA, f = 100 MHz) MPN3411	R_F	–	–	10	Ohms
MPN3412		–	–	15	
Series Inductance (Note 2) (f = 250 MHz) (Measured at Lead Stop ≈ 1/8″)	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF

NOTES

1. C_T is measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
2. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).



PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

TYPICAL ELECTRICAL CHARACTERISTICS

FORWARD RESISTANCE versus CURRENT

FIGURE 1 – MPN3411

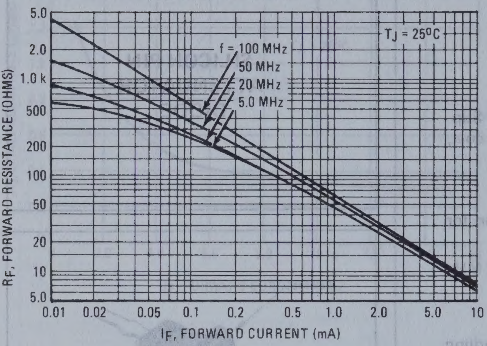


FIGURE 2 – MPN3412

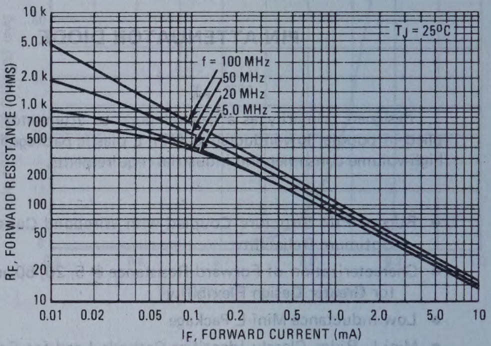


FIGURE 3 – FREQUENCY versus CAPACITANCE

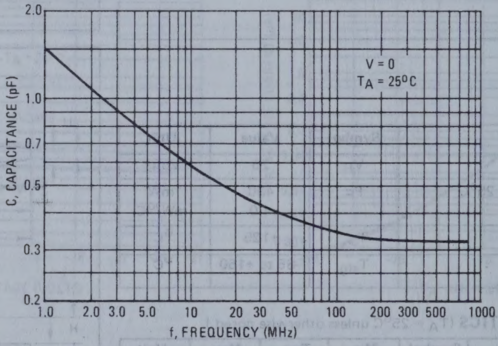
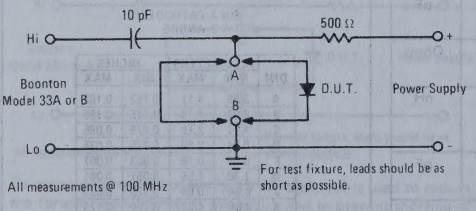


FIGURE 4 – FORWARD RESISTANCE TEST METHOD


10 pF
Hi
500 Ω
+
A
B
D.U.T.
Power Supply
Boonton
Model 33A or B
Lo
-
For test fixture, leads should be as short as possible.
All measurements @ 100 MHz

To measure forward resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_F) can now be calculated from:

$$R_F = \frac{KG}{C^2}$$

Where:

G – in micromhos,
C – in pF,
R_F – in ohms
K – frequency dependent constant – Boonton 75A instruction manual.

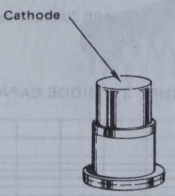
MPN3601 (SILICON)

MICROWAVE SILICON PIN DIODE

. . . designed for band switching, general-purpose switching, and attenuator applications where a hermetic low parasitic package is desirable.

- Supplies in Ceramic Pill Package for Microwave Applications
- Rugged PIN Structure Coupled with Wirebond Construction for Optimum Reliability
- Very Low Series Resistance @ 100 MHz – R_S = 0.34 Ohms (Typ) @ I_F = 10 mA
- Low Series Inductance – L_S = 3.0 nH (Typ) @ f = 250 MHz
- Completely Switched at V_R = -2 V

MICROWAVE
SILICON PIN
SWITCHING DIODE



MAXIMUM RATINGS

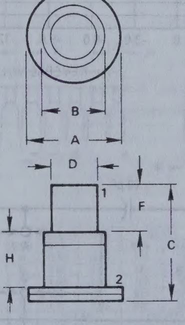
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	35	–	–	Volts
Diode Capacitance (Note 1) (V_R = 20 Vdc, f = 1.0 MHz)	C_T	–	–	1.0	pF
Series Resistance (Figure 5) (I_F = 10 mA, f = 100 MHz)	R_S	–	0.34	0.7	Ohms
Reverse Leakage Current (V_R = 25 Vdc)	I_R	–	–	0.1	μA
Series Inductance (Note 2) (f = 250 MHz)	L_S	–	0.8	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.15	–	pF

NOTES

1. C_T is measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
2. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	2.97	3.30	0.117	0.130
B	1.96	2.21	0.077	0.087
C	3.78	4.09	0.149	0.161
D	1.52	1.68	0.060	0.066
F	1.50	1.65	0.059	0.065
H	1.78	1.93	0.070	0.076

CASE 45-01

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SERIES RESISTANCE

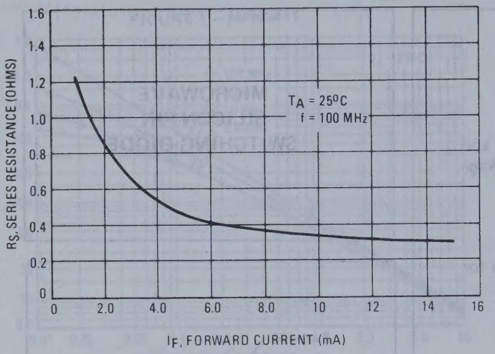


FIGURE 2 – FORWARD VOLTAGE

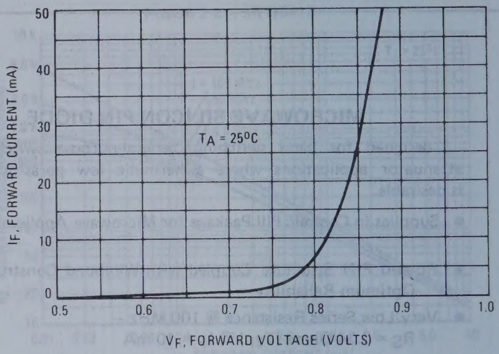


FIGURE 3 – DIODE CAPACITANCE

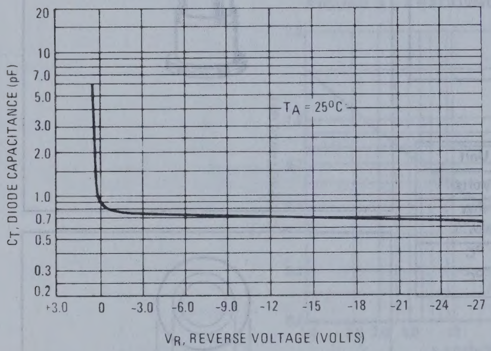


FIGURE 4 – LEAKAGE CURRENT

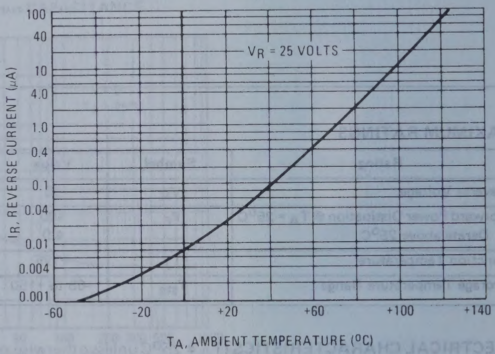
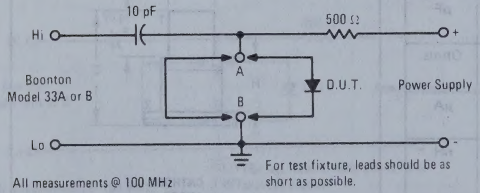


FIGURE 5 – FORWARD SERIES RESISTANCE TEST METHOD



10 pF
500 Ω
Hi
+
A
Boonton
Model 33A or B
D.U.T.
Power Supply
B
Lo
-
For test fixture, leads should be as short as possible.
All measurements @ 100 MHz

To measure series resistance, a 10 pF capacitor is used to reduce the forward capacitance of the circuit and to prevent shorting of the external power supply through the bridge. The small signal from the bridge is prevented from shorting through the power supply by the 500-ohm resistor. The resistance of the 10 pF capacitor can be considered negligible for this measurement.

1. The RF Admittance Bridge (Boonton 33A or B) must be initially balanced, with the test circuit connected to the bridge test terminals. The conductance scale will be set at zero and the capacitance scale will be set at 120 pF, as required when using the 100 MHz test coil.
2. Use a short length of wire to short the test circuit from point "A" to "B". Then connect the power supply providing 10 mA of bias current to the test circuit.
3. Adjust the capacitance scale arm of the bridge and the "G" zero control for a minimum null on the "null meter". The null occurs at approximately 130 pF.
4. Replace the wire short with the device to be tested. Bias the device to a forward conductance state of 10 mA.
5. Obtain a minimum null on the "null meter", with the capacitance and conductance scale adjustment arms.
6. Read conductance (G) direct from the scale. Now read the capacitance value from the scale (≈ 130 pF) and subtract 120 pF which yields capacitance (C). The forward resistance (R_S) can now be calculated from:

$$R_S = \frac{2.533\,G}{C^2}$$

Where:
G – in micromhos,
C – in pF,
R_S – in ohms

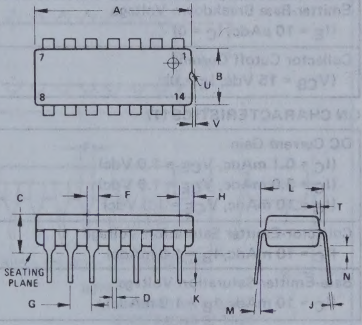
MPQ918 (SILICON)

QUAD DUAL IN-LINE NPN SILICON ANNULAR HIGH FREQUENCY AMPLIFIER TRANSISTORS

. . . designed for low-level, high-gain amplifier applications.

- Low Noise Figure — @ I_C = 1.0 mAdc
  NF = 4.0 dB (Typ)
- High Current-Gain—Bandwidth Product —
  f_T = 850 MHz (Typ) @ I_C = 4.0 mAdc
- Transistors Similar to 2N918
- TO-116 Package — Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL IN-LINE NPN SILICON HIGH FREQUENCY AMPLIFIER TRANSISTORS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	–	10^0	–	10^0
N	.64	.89	.025	.035
T	7^0 TYP		7^0 TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel

CASE 646
TO-116

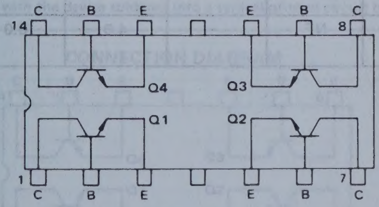
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ $T_A = 25^oC$ (1) Derate above 25^oC	P_D	500 4.0	900 7.2	mW $mW/^oC$
Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	6.7 0.825	2.4 19.2	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 134	$^oC/W$ $^oC/W$
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

CONNECTION DIAGRAM



THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)		–	110	–	
(I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)		20	80	–	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		–	50	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.11	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.84	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	850	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	0.75	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	1.1	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_G = 400 Ohms, f = 60 MHz)	NF	–	4.0	6.0	dB

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MPQ1000

QUAD DUAL-IN-LINE NPN LED DISPLAY DRIVER

. . . designed for DC to VHF amplifier applications.

- DC Current Gain Specified — 10 to 150 mAdc
- Low Collector-Cutoff Current — I_{CBO} = 50 nAdc (Max) @ V_{CB} = 30 Vdc
- Collector Breakdown Voltages — BV_{CEO} = 20 Vdc (Min) BV_{CBO} = 40 Vdc (Min)
- TO-116 Packaging — Compact Size Compatible With IC Automatic Insertion Equipment

MAXIMUM RATINGS

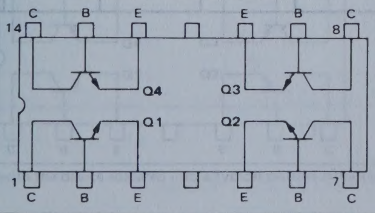
Rating	Symbol	Value		Unit
Common-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	650 5.18	1250 10	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

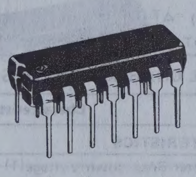
Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance (1)	Each Die Effective, 4 Die	125 41.6	193 100	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	30 2.0	60 24	% %

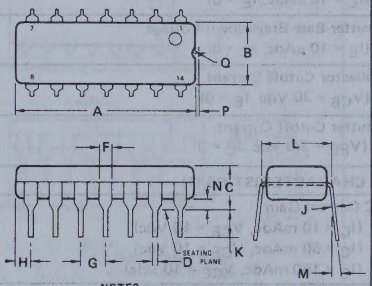
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

CONNECTION DIAGRAM



QUAD DUAL-IN-LINE NPN LED DISPLAY DRIVER





NOTES:

1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperatures can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on **page 1**. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current ($V_{EB} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	–	–	
($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc)		50	–	–	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		40	–	–	
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	–	–	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	175	–	–	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	–	8.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ib}	–	–	30	pF

(1) Pulse Test: Pulse Width $\leq 300\ \mu$s, Duty Cycle $\leq 2.0\%$.

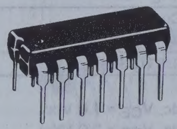
MPQ1050 (SILICON)

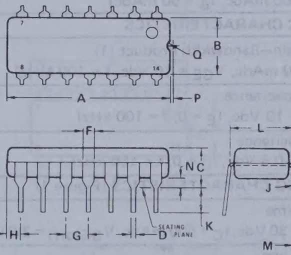
QUAD DUAL-IN-LINE NPN SILICON HIGH-CURRENT SWITCHING TRANSISTOR

. . . designed for high-current, high-speed switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = 0.45$ Vdc (Max) @ $I_C = 500$ mAdc
- High Current-Gain — Bandwidth Product — $f_T = 200$ MHz (Min) @ $I_C = 50$ mAdc
- Fast Switching Speeds @ $I_C = 500$ mAdc
  - $t_{on} = 35$ ns (Max)
  - $t_{off} = 45$ ns (Max)
- TO-116 Package — Compact Size Compatible with I_C Automatic Insertion Equipment

QUAD DUAL-IN-LINE NPN SILICON HIGH-CURRENT SWITCHING TRANSISTOR





NOTES:

1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

CASE 646
TO-116

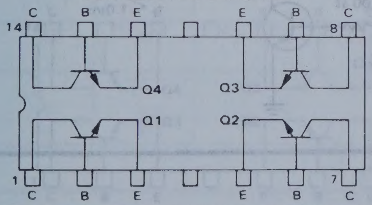
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Emitter Voltage	V_{CES}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	750 5.98	1700 13.6	mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance (1)	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

CONNECTION DIAGRAM



(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperatures can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} \pm P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$$

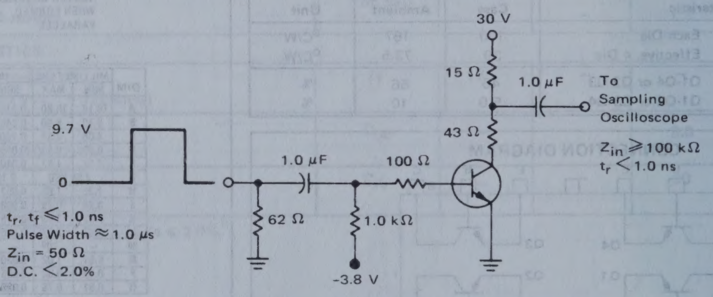
Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 µAdc, V_{BE} = 0)	BV_{CES}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	500	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 30	 – –	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	80	pF
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, $V_{BE(off)}$ = 3.8 Vdc, I_{B1} = 50 mAdc)	t_{on}	–	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, $I_{B1} = I_{B2}$ = 50 mAdc)	t_{off}	–	45	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



MPQ2221 (SILICON)
MPQ2222

For Specifications, See MHQ2221 Data.

MPQ2369 (SILICON) For Specifications, See MHQ2369 Data.

MPQ2483 (SILICON)
MPQ2484

QUAD DUAL IN-LINE NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for low-level, high-gain amplifier applications.

- Low Noise Figure — @ I_C = 10 μAdc
  NF = 3.0 dB (Typ) — MPQ2483
  = 2.0 dB (Typ) — MPQ2484
- Transistors Similar to 2N2483 and 2N2484
- TO-116 Package — Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL IN-LINE NPN SILICON AMPLIFIER TRANSISTORS

MAXIMUM RATINGS

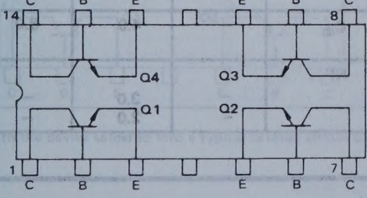
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

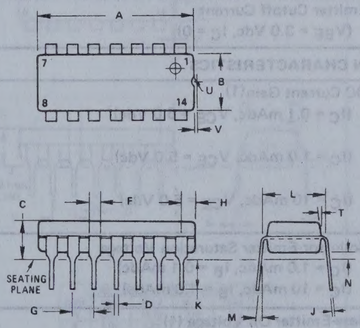
(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	134	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	-	10°	-	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\,P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	–	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483 MPQ2484		100 200	– –	– –	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483 MPQ2484		150 300	– –	– –	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ2483 MPQ2484		150 300	– –	– –	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	– –	0.13 0.15	0.35 0.5	Vdc
Base-Emitter On Voltage (1) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	– –	0.58 0.70	0.7 0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	100	–	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	1.8	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	4.0	8.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	MPQ2483 MPQ2484	NF	– –	3.0 2.0	– –	dB

(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

MPQ2906, MPQ2907 (SILICON)

For Specifications, See MHQ2906 Data.

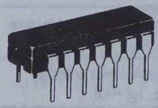
MPQ3303 (SILICON)

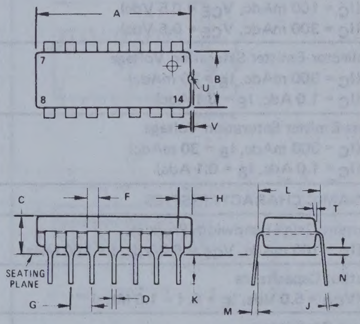
QUAD DUAL-IN-LINE NPN SILICON ANNULAR LOW-VOLTAGE HIGH-CURRENT TRANSISTORS

. . . designed for high-current, high-speed switching, and MOS translator applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- High Current-Gain–Bandwidth Product –
  f_T = 400 MHz (Min) @ I_C = 100 mAdc
- Fast Switching Speeds at High Currents –
  t_{on} = 15 ns (Max) @ I_C = 1.0 Adc
  t_{off} = 25 ns (Max) @ I_C = 1.0 Adc
- Transistor Similar to 2N3303
- TO-116 Package – Compact Size Compatible with I_C Automatic Insertion Equipment
- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 25 Vdc with appropriate parameter modifications as a special

QUAD DUAL-IN-LINE NPN SILICON LOW VOLTAGE HIGH CURRENT SWITCHING TRANSISTORS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	–	10°	–	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

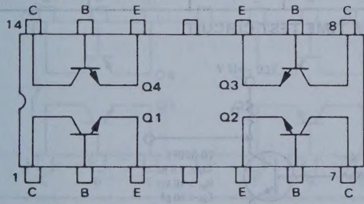
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	12		Vdc
Collector-Base Voltage	V_{CB}	25		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	650 5.2	1250 10	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	125 41.6	193* 100*	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	30 2.0	60 25	% %

CONNECTION DIAGRAM



*$R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices coupling of heat between die occurs. The junction temperatures can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\ P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

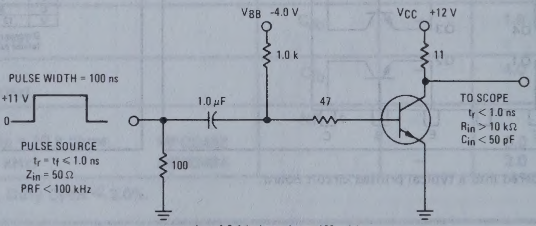
(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 0.5 Vdc)		30	45	–	
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc)		40	55	200	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.22	0.33	
(I_C = 1.0 Adc, I_B = 0.1 Adc)		–	0.52	0.7	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.87	1.1	
(I_C = 1.0 Adc, I_B = 0.1 Adc)		–	1.04	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	500	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	22	30	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc, $V_{BE(off)}$ = 4.0 Vdc, I_{B1} = 100 mAdc)	t_{on}	–	12	15	ns
Turn-Off Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc, $I_{B1} = I_{B2}$ = 100 mAdc)	t_{off}	–	18	25	ns

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



$I_C \approx 1.0$ Adc, $I_{B1} \approx I_{B2} \approx 100$ mAdc

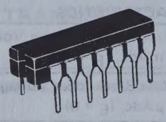
MPQ3467 (SILICON)

QUAD DUAL IN-LINE PNP SILICON ANNULAR MEMORY DRIVER TRANSISTORS

. . . designed for medium-current, high-speed switching, ferrite core and plated wire memory driver, and MOS translator applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 500 mAdc
- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Fast Switching @ I_C = 500 mAdc
  - t_{on} = 40 ns (Max)
  - t_{off} = 90 ns (Max)
- Transistor Similar to 2N3467
- TO-116 Package — Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE PNP SILICON MEMORY DRIVER TRANSISTORS



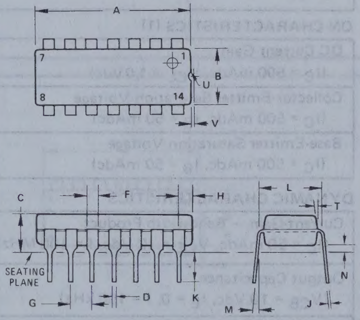
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Common-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	750 5.98	1700 13.6	mW mW/^oC
Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.25 10	3.2 25.6	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance (1)	Each Die Effective, 4 Die	100 39	167 73.5	^oC/W ^oC/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	45 5.0	55 10	% %

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

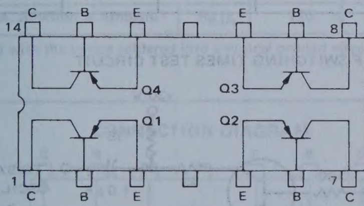


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	–	10^0	–	10^0
N	.64	.89	.025	.035
T	7^0 TYP		7^0 TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

CONNECTION DIAGRAM



THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperatures can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipated in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

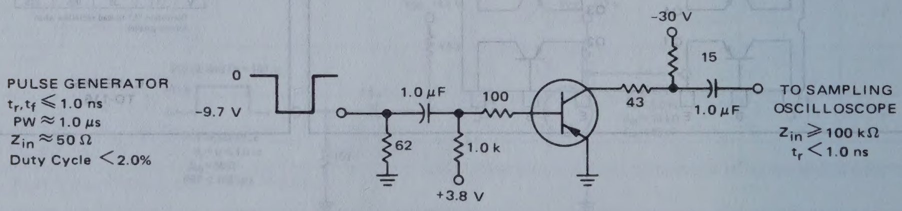
Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	200	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	200	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.23	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	–	0.90	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	190	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	55	80	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = 3.8 Vdc)	t_{on}	–	–	40	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, $I_{B1} = I_{B2}$ = 50 mAdc)	t_{off}	–	–	90	ns

(1) Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



MPQ3546 (SILICON)

For Specifications, See MHQ3546 Data.

MPQ3725 (SILICON)
MPQ3725A

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTORS

. . . designed for medium-current, high speed switching and driver applications.

- Collector-Emitter Breakdown Voltage @ I_C = 10 mAdc –
  BV_{CEO} = 40 Vdc (Min) – MPQ3725
  = 50 Vdc (Min) – MPQ3725A
- Fast Switching Times @ I_C = 500 mAdc –
  t_{on} = 20 ns (Typ)
  t_{off} = 50 ns (Typ)

QUAD DUAL-IN-LINE

NPN SILICON CORE DRIVER TRANSISTORS

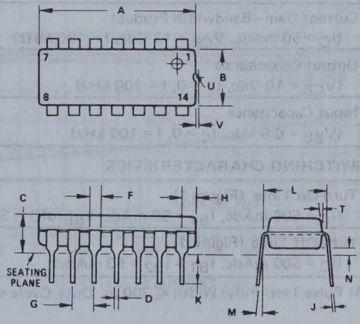
MAXIMUM RATINGS

Rating	Symbol	MPQ3725	MPQ3725A	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C
		One Transistor	Four Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max		Unit
		One Transistor	Effective For Four Transistors	
Thermal Resistance, Junction to Ambient*	$R_{\theta JA}$	125	50	°C/W

*$R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

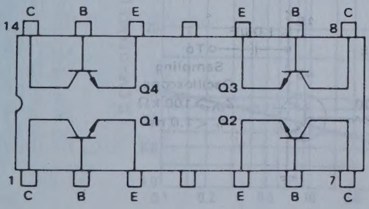


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	-	10°	-	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

CONNECTION DIAGRAM



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MPQ3725 MPQ3725A	BV_{CEO}	40 50	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	MPQ3725 MPQ3725A	BV_{CES}	60 70	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	—	—	0.5	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				—
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MPQ3725 MPQ3725A		35 40	75 80	200 —	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	MPQ3725 MPQ3725A		25 30	45 50	— —	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	—	0.32	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	0.8	0.9	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPQ3725 MPQ3725A	f_T	250 200	275 250	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	5.1	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	62	80	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (Figure 1) (I_C = 500 mAdc, I_{B1} = 50 mAdc, V_{BE}(off) = 3.8 Vdc)		t_{on}	—	20	35	ns
Turn-Off Time (Figure 1) (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	—	50	60	ns

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT

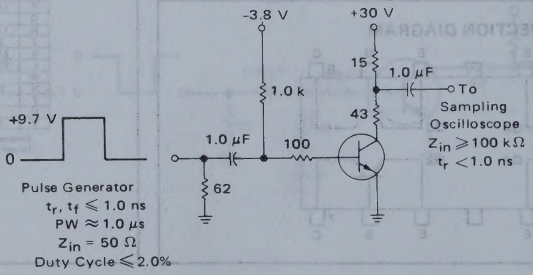

-3.8 V
+30 V
15
1.0 μF
To
Sampling
Oscilloscope
Z_{in} ⩾ 100 kΩ
t_r < 1.0 ns
1.0 k
43
+9.7 V
0
1.0 μF
100
62
Pulse Generator
t_r, t_f ⩽ 1.0 ns
PW ≈ 1.0 μs
Z_{in} = 50 Ω
Duty Cycle ⩽ 2.0%

FIGURE 2 – DC CURRENT GAIN

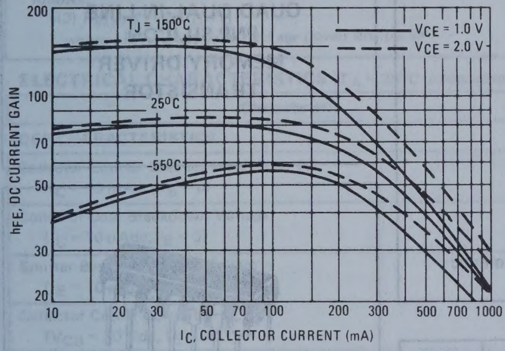


FIGURE 3 – COLLECTOR SATURATION REGION

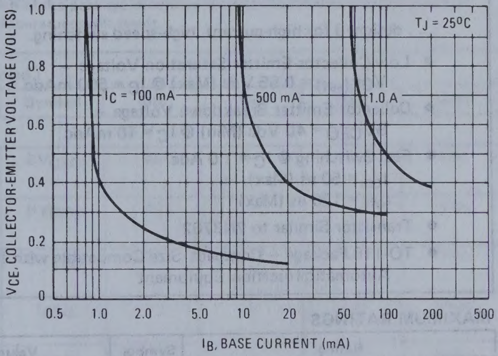


FIGURE 4 – "ON" VOLTAGES

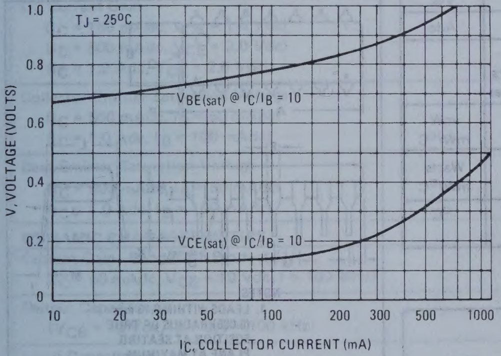


FIGURE 5 – TEMPERATURE COEFFICIENTS

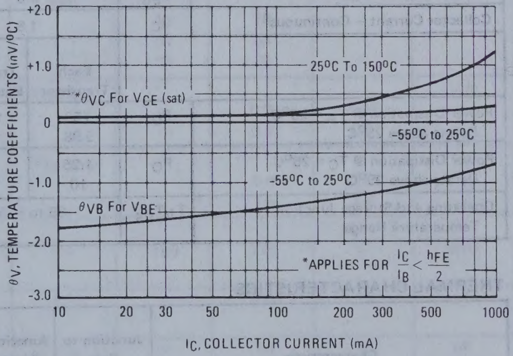
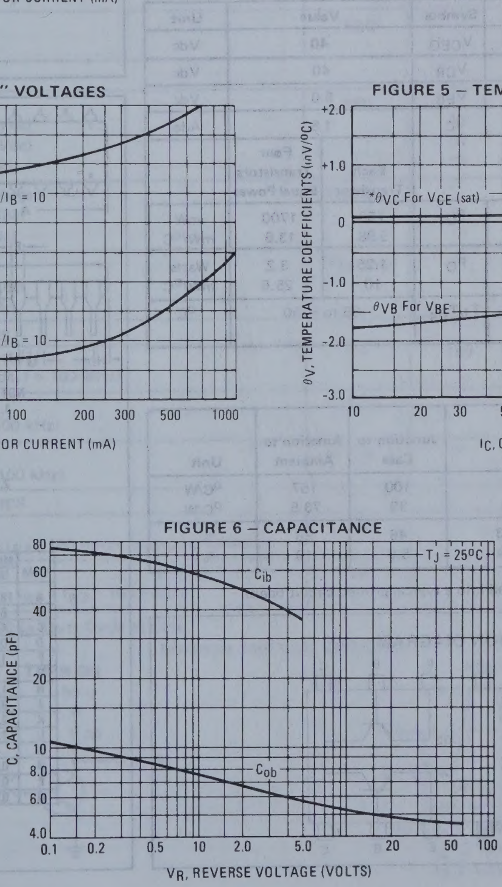


FIGURE 6 – CAPACITANCE



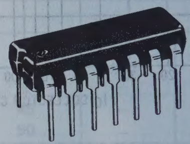
MPQ3762 (SILICON)

QUAD DUAL IN-LINE PNP SILICON ANNULAR MEMORY DRIVER TRANSISTOR

. . . designed for high-current, high-speed switching.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.55 Vdc (Max) @ I_C = 500 mAdc
- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Fast Switching @ I_C = 1.0 Adc
  t_{on} = 50 ns (Max)
  t_{off} = 120 ns (Max)
- Transistor Similar to 2N3762
- TO-116 Package — Compact Size Compatible with IC Automatic Automatic Insertion Equipment

QUAD DUAL-IN-LINE PNP SILICON MEMORY DRIVER TRANSISTOR



MAXIMUM RATINGS

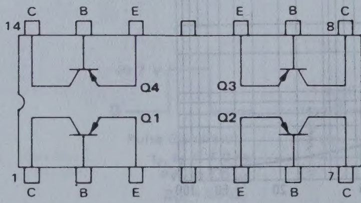
Rating	Symbol	Value		Unit
Common-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ $T_A = 25^\circ C$ Derate above 25°C	P_D	750 5.98	1700 13.6	mW mW/°C
Power Dissipation @ $T_C = 25^\circ C$ Derate above 25°C	P_D	1.25 10	3.2 25.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

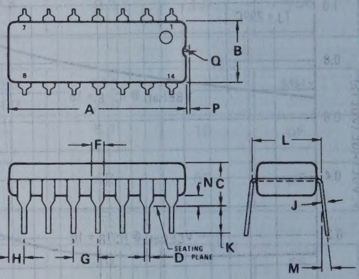
THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance (1)	Each Die	100	167	°C/W
	Effective, 4 Die	39	73.5	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	46	56	%
	Q1-Q2 or Q3-Q4	5.0	10	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

CONNECTION DIAGRAM





NOTES:

1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperatures can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\,P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	40	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
Emitter-Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	—	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				—
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		35	70	—	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		30	65	—	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		20	35	—	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.3	0.55	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	0.6	0.9	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.9	1.25	
(I_C = 1.0 Adc, I_B = 100 mAdc)		—	1.0	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	275	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	9.0	15	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	55	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc, $V_{BE(off)}$ = 2.0 Vdc)	t_{on}	—	—	50	ns
Turn-Off Time (Figure 2) (V_{CC} = 30 Vdc, I_C = 1.0 Adc, $I_{B1} = I_{B2}$ = 100 mAdc)	t_{off}	—	—	120	ns

(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON

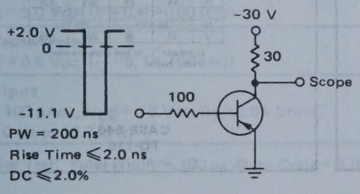
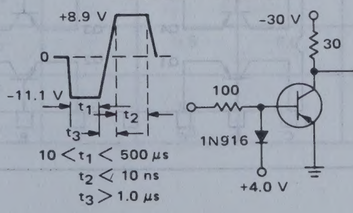


FIGURE 2 — TURN-OFF



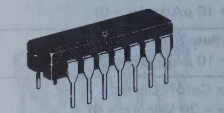
MPQ3798 (SILICON)
MPQ3799

QUAD DUAL-IN-LINE PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for low-level, low-noise amplifier applications.

- DC Current Gain Specified – 10 μAdc to 10 mAdc
  h_{FE} = 150 (Min) @ I_C = 500 μAdc – MPQ3798
  = 300 (Min) @ I_C = 500 μAdc – MPQ3799
- Low Capacitance –
  C_{ob} = 2.3 pF (Typ) @ V_{CB} = 5.0 Vdc
- Low Noise Figure – NF = 1.5 dB (Typ) @ I_C = 100 μAdc – MPQ3799
- Transistors Similar to 2N3798 and 2N3799
- TO-116 Package – Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE PNP SILICON AMPLIFIER TRANSISTORS



MAXIMUM RATINGS

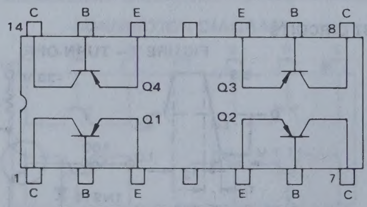
Rating	Symbol	MPQ3798	MPQ3799	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C(1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

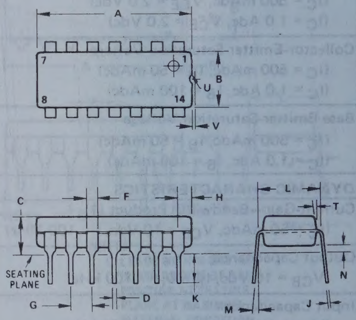
(1) Second breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	134	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

CONNECTION DIAGRAM





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	-	10°	-	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperatures can be calculated as follows:

$$(1)\quad \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\quad R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\quad \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\,P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\quad R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPQ3798	BV_{CEO}	40	–	–	Vdc
	MPQ3799		60	–	–	
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 10 µAdc, V_{CE} = 5.0 Vdc)	MPQ3798	h_{FE}	100	–	–	
	MPQ3799		225	–	–	
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc)	MPQ3798		150	–	–	
	MPQ3799		300	–	–	
(I_C = 500 µAdc, V_{CE} = 5.0 Vdc)	MPQ3798		150	–	–	
	MPQ3799		300	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ3798		125	–	–	
	MPQ3799		250	–	–	
Collector-Emitter Saturation Voltage (I_C = 100 µAdc, I_B = 10 µAdc)		$V_{CE(sat)}$	–	0.12	0.2	Vdc
(I_C = 1.0 mAdc, I_B = 100 µAdc)			–	0.15	0.25	
Base-Emitter Saturation Voltage (I_C = 100 µAdc, I_B = 10 µAdc)		$V_{BE(sat)}$	–	0.58	0.7	Vdc
(I_C = 1.0 mAdc, I_B = 100 µAdc)			–	0.66	0.8	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	60	130	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.3	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	5.5	8.0	pF
Noise Figure (I_C = 100 µAdc, V_{CE} = 10 Vdc, R_S = 3.0 k Ohms, f = 10 Hz to 15.7 kHz)	MPQ3798	NF	–	2.5	–	dB
	MPQ3799		–	1.5	–	

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle = 2.0%.

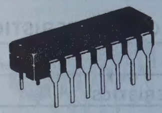
MPQ3904 (SILICON)

QUAD DUAL-IN-LINE
NPN SILICON ANNULAR
AMPLIFIER/SWITCH TRANSISTOR

. . . designed for low current amplifier and switching applications.

- Transistors Similar to 2N3903, 2N3904, 2N3946
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = 0.2$ Vdc (Max) @ $I_C = 10$ mAdc
- Collector-Emitter Breakdown Voltage — $BV_{CEO} = 40$ Vdc (Min) @ $I_C = 1.0$ mAdc
- DC Current Gain Specified — 0.1 to 10 mAdc
- TO-116 Plastic Package — Compact Size Compatible with IC Automatic Insertion Equipment

QUAD DUAL-IN-LINE NPN SILICON AMPLIFIER/SWITCH TRANSISTOR



MAXIMUM RATINGS

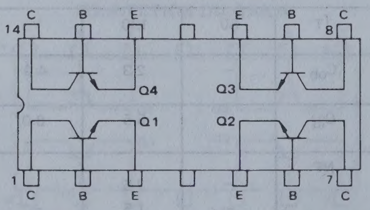
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	200	mAdc

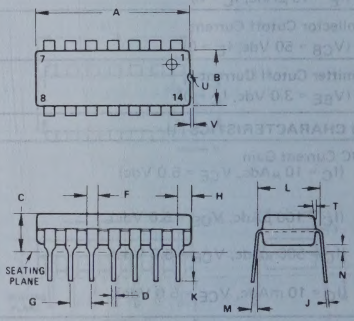
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	500 4.0	900 7.2	mW mW/$^{\circ}C$
Total Power Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	825 6.7	2.4 19.2	Watts mW/$^{\circ}C$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^{\circ}C$

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	$^{\circ}C/W$
	Effective, 4 Die	52	139	$^{\circ}C/W$
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

CONNECTION DIAGRAM





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	–	10°	–	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel

CASE 646
TO-116

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Boltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 40 Vdc, I_C = 0)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 75	 90 160 200	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.1	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.65	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	300	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	2.0	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	4.0	8.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (I_C = 10 mAdc $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = 1.0 mAdc)	t_{on}	–	37	–	ns
Turn-Off Time (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	–	136	–	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

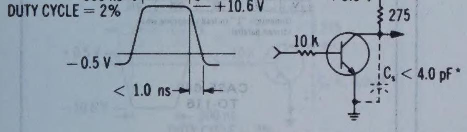
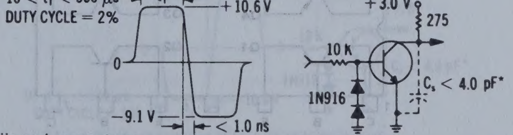


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

MPQ3906 (SILICON)

QUAD DUAL-IN-LINE PNP SILICON ANNULAR AMPLIFIER/SWITCH TRANSISTOR

. . . designed for low current amplifier and switching applications.

- Transistors Similar to 2N3905, 2N3906, 2N3250
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = 0.25$ Vdc (Max) @ $I_C = 10$ mAdc
- Collector-Emitter Breakdown Voltage — $BV_{CEO} = 40$ Vdc (Min) @ $I_C = 1.0$ mAdc
- DC Current Gain Specified — 0.1 to 10 mAdc
- TO-116 Plastic Package — Compact Size Compatible with IC Automatic Insertion Equipment

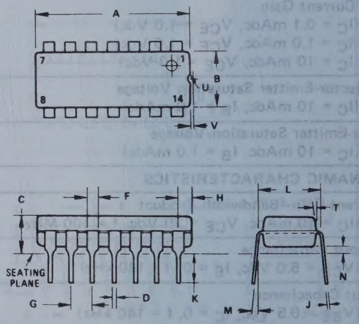
QUAD DUAL-IN-LINE PNP SILICON AMPLIFIER/SWITCH TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Total Power Dissipation @ $T_A = 25^\circ C$ Derate above $25^\circ C$	P_D	500 4.0	900 7.2	mW $mW/^\circ C$
Total Power Dissipation @ $T_C = 25^\circ C$ Derate above $25^\circ C$	P_D	825 6.7	2.4 19.2	Watts $mW/^\circ C$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ C$

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	151 52	250 139	$^\circ C/W$ $^\circ C/W$
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %

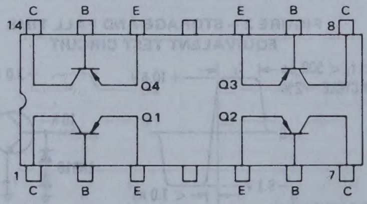


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	-	10°	–	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

CONNECTION DIAGRAM



THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

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$$(1)\quad \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\quad R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\quad \Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\,P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\quad R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
($I_C = 0.1$ mAdc, $V_{CE} = 1.0$ Vdc)		40	160	–	
($I_C = 1.0$ mAdc, $V_{CE} = 1.0$ Vdc)		60	180	–	
($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)		75	200	–	
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	–	0.1	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	–	0.65	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	200	250	–	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 140 kHz)	C_{ob}	–	3.3	4.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 140 kHz)	C_{ib}	–	4.8	10	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) ($I_C = 10$ mAdc, $V_{BE(off)} = 0.5$ Vdc, $I_{B1} = 1.0$ mAdc)	t_{on}	–	43	–	ns
Turn-Off Time (Figure 2) ($I_C = 10$ mAdc, $I_{B1} = I_{B2} = 1.0$ mAdc)	t_{off}	–	155	–	ns

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

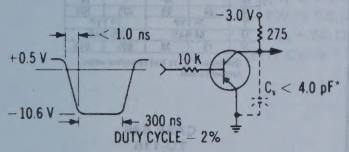
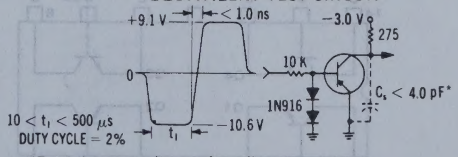


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

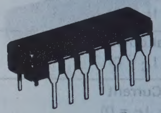
MPQ4003 (SILICON)
MPQ4004

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTORS

. . . designed for medium current, high-speed switching and driver applications.

- High Collector-Emitter Breakdown Voltage @ I_C = 10 mAdc –
  BV_{CEO} = 40 Vdc (Min) – MPQ4003
  = 50 Vdc (Min) – MPQ4004
- Fast Switching Times @ I_C = 500 mAdc –
  t_{on} = 25 ns (Typ)
  t_{off} = 60 ns (Typ)

NPN SILICON DUAL-IN-LINE CORE DRIVER TRANSISTORS



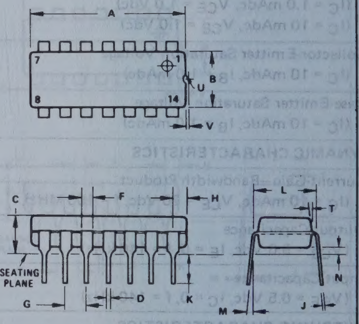
MAXIMUM RATINGS

Rating	Symbol	MPQ4003	MPQ4004	Unit
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Collector-Emitter Voltage	V_{CES}	60	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150		°C
		One Transistor	Equal Transistors Equal Power	
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	1.0 8.0	2.5 20	Watts mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max		Unit
		One Transistor	Effective For Four Transistors	
Thermal Resistance, Junction to Ambient*	$R_{\theta JA}$	125	50	°C/W

*$R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

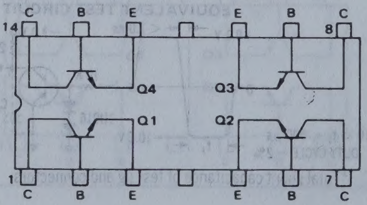


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.03	18.79	.710	.740
B	6.09	6.60	.240	.260
C	4.06	4.57	.160	.180
D	.38	.51	.015	.020
F	1.02	1.65	.040	.065
G	2.54 BSC		.100 BSC	
H	1.32	1.83	.052	.072
J	.23	.36	.009	.014
K	2.92	3.43	.115	.135
L	7.37	7.87	.290	.310
M	-	10°	-	10°
N	.64	.89	.025	.035
T	7° TYP		7° TYP	
U	.64 RAD		.025 RAD	
V	.13	.38	.005	.015

Dimension "L" to lead centerline when formed parallel.

CASE 646
TO-116

CONNECTION DIAGRAM

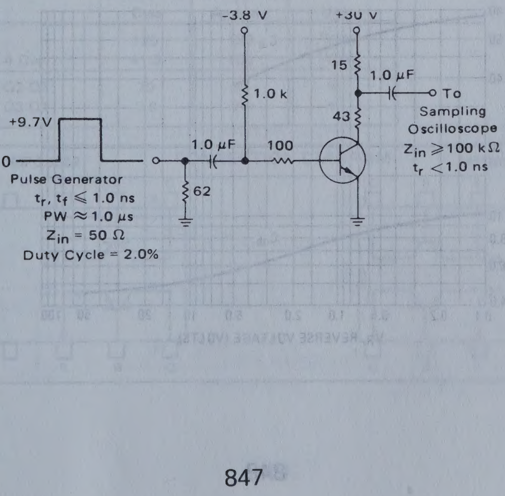


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MPQ4003 MPQ4004	BV_{CEO}	40 50	– –	– –	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	MPQ4003 MPQ4004	BV_{CES}	60 70	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	–	–	0.5	μAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		h_{FE}	 35 25	 75 45	 200 –	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	–	0.32	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	0.8	0.9	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	5.1	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	62	80	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (Figure 1) (I_C = 500 mAdc, I_{B1} = 50 mAdc, $V_{BE(off)}$ = 3.8 Vdc)		t_{on}		25	40	ns
Turn-Off Time (Figure 1) (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	–	60	75	ns

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



-3.8 V
+30 V
15
1.0 μF
1.0 k
To
Sampling
Oscilloscope
$Z_{in} \geq 100\ k\Omega$
$t_r < 1.0$ ns
43
+9.7V
0
1.0 μF
100
62
Pulse Generator
t_r, t_f ⩽ 1.0 ns
PW ≈ 1.0 μs
Z_{in} = 50 Ω
Duty Cycle = 2.0%

FIGURE 2 – DC CURRENT GAIN

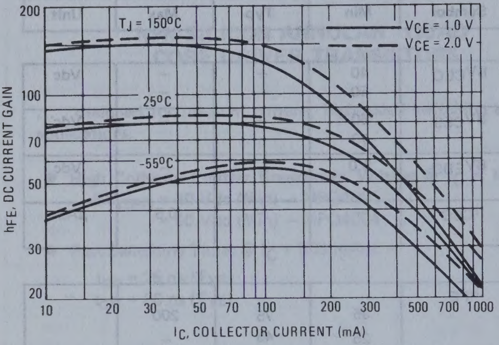


FIGURE 3 – COLLECTOR SATURATION REGION

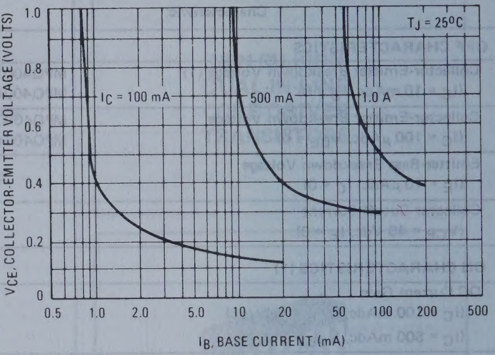


FIGURE 4 – "ON" VOLTAGES

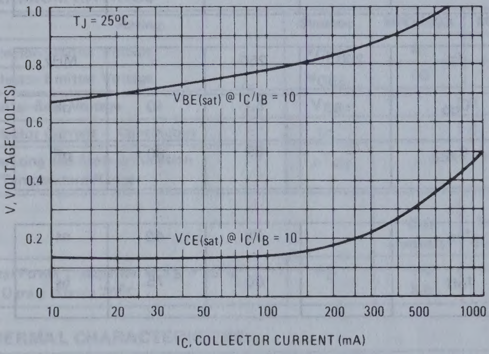


FIGURE 5 – TEMPERATURE COEFFICIENTS

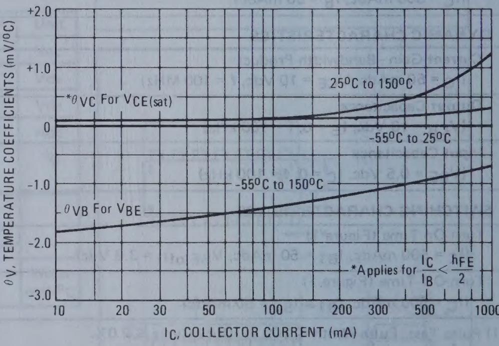
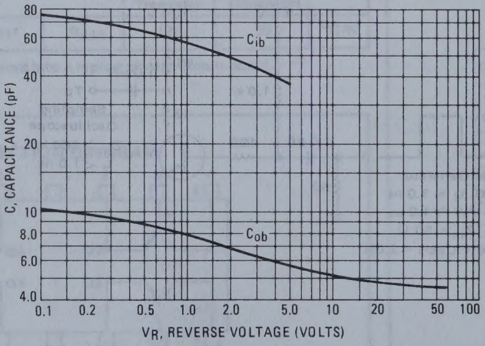


FIGURE 6 – CAPACITANCE



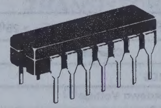
MPQ6001 (SILICON)
MPQ6002
MPQ6501
MPQ6502

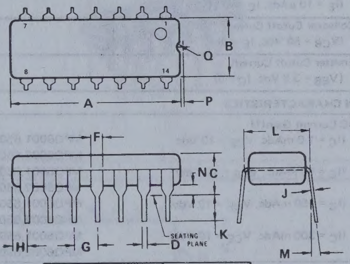
QUAD DUAL-IN-LINE SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTORS

. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- DC Current Gain Specified – 1.0 to 300 mAdc
- High Current-Gain–Bandwidth Product
  f_T = 400 MHz (Typ) @ I_C = 50 mAdc
- NPN Transistor Similar to 2N2218 or 2N2219
- PNP Transistor Similar to 2N2904 or 2N2905
- TO-116 Package – Compact Size Compatible with IC Automatic Insertion Equipment
- MPQ6501, MPQ6502 Matching Characteristics Available as Specials on Q1-Q4 and Q2-Q3.

QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTORS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10^0	–	10^0
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

NOTES:

1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

CASE 646

MAXIMUM RATINGS

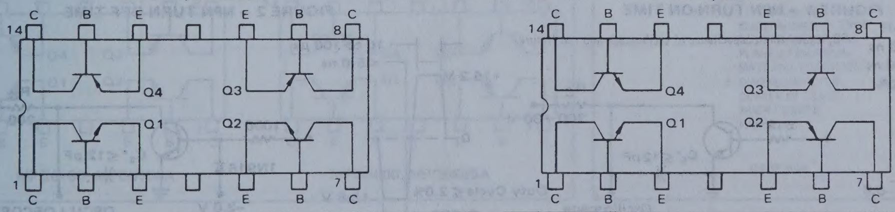
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	650 5.18	1250 10	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	3.0 24	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	125 41.6	193 100	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	30 2.0	60 24	% %

CONNECTION DIAGRAM


MPQ6001, MPQ6002

MPQ6501, MPQ6502

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted)

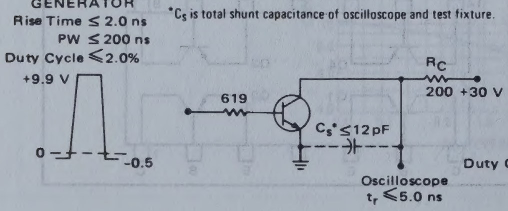
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	30	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	30	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc	MPQ6001,6501		25	35	–	
	MPQ6002,6502		50	65	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPQ6001,6501		35	50	–	
	MPQ6002,6502		75	90	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MPQ6001,6501		40	65	–	
	MPQ6002,6502		100	120	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MPQ6001,6501		20	25	–	
	MPQ6002,6502		30	35	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.2	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	0.35	1.4	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.9	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	1.0	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	350	–	MHz
Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	PNP		–	6.0	8.0	
	NPN		–	4.5	8.0	
Input Capacitance		C_{ib}				pF
(V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	PNP		–	20	30	
	NPN		–	17	30	
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1)		t_{on}	–	30	–	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, $I_{B1} = I_{B2}$ = 15 mAdc, Figure 2)		t_{off}	–	225	–	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2%.

NPN SATURATED SWITCHING TIME TEST CIRCUITS

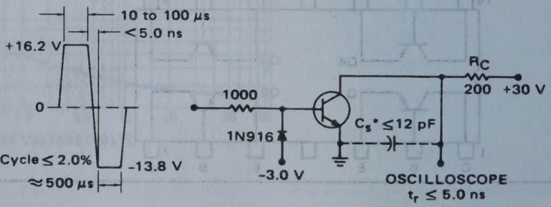
For PNP Switching Tests, reverse the diodes, voltage polarities, and input pulses.

FIGURE 1 — NPN TURN-ON TIME



*C_s is total shunt capacitance of oscilloscope and test fixture.

FIGURE 2 — NPN TURN-OFF TIME



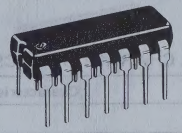
MPQ6100, MPQ6100A (SILICON)
MPQ6600, MPQ6600A

QUAD DUAL-IN-LINE SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTORS

. . . designed for DC to VHF amplifier applications and complementary circuitry.

- DC Current Gain Specified – 100 µAdc to 10 mAdc
- Current-Gain–Bandwidth Product – f_T = 125 MHz (Typ) @ I_C = 0.5 mAdc
- NPN Transistor Similar to 2N2483 or 2N2484
- PNP Transistor Similar to 2N3798 or 2N3799
- MPQ6600,A Matching Characteristics Available as Specials on Q1-Q4 and Q2-Q3

QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTORS

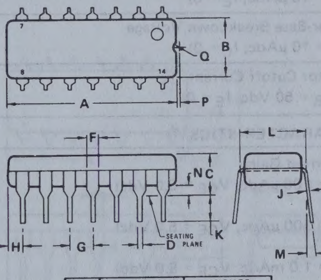


MAXIMUM RATINGS

Rating	Symbol	MPQ6100 MPQ6600	MPQ6100A MPQ6600A	Unit
Collector-Emitter Voltage	V_{CEO}	40	45	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ $T_A = 25^{\circ}C$ (1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Power Dissipation @ $T_C = 25^{\circ}C$ Derate above 25°C	P_D	0.825 6.7	2.4 19.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die Effective, 4 Die	134 52	250 151	°C/W °C/W
Coupling Factors	Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	34 2.0	70 26	% %



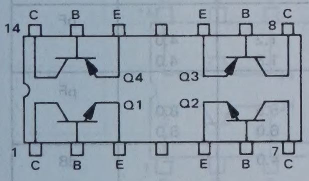
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

NOTES:

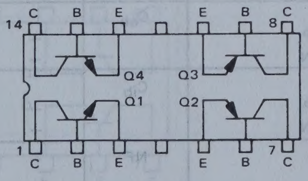
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL

CASE 646

CONNECTION DIAGRAM



MPQ6100, MPQ6100A



MPQ6600, MPQ6600A

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	MPQ6100,6600	BV_{CEO}	40	–	–	Vdc
	MPQ6100A,6600A		45	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc

ON CHARACTERISTICS (1)

DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600	h_{FE}	50	95	–	–
	MPQ6100A,6600A		100	200	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600		75	140	–	
	MPQ6100A,6600A		150	300	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600		75	140	–	
	MPQ6100A,6600A		150	300	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPQ6100,6600		60	110	–	
	MPQ6100A,6600A		125	275	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$	–	0.1	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$	–	0.65	0.8	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	50	125	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	PNP	C_{ob}	–	1.2	4.0	pF
	NPN		–	1.8	4.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	PNP	C_{ib}	–	5.5	8.0	pF
	NPN		–	6.0	8.0	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)		NF	–	4.0	–	dB

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

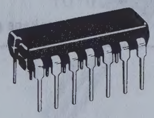
MPQ6700 (SILICON)

QUAD DUAL-IN-LINE SILICON ANNULAR COMPLEMENTARY PAIR TRANSISTOR

. . . designed for DC to VHF amplifier applications and complementary circuitry.

- DC Current Gain Specified – 0.1 to 10 mAdc
- Current-Gain – Bandwidth Product –
  f_T = 200 MHz (Min) @ I_C = 10 mAdc
- NPN Transistor Similar to 2N3903 or 2N3904
- PNP Transistor Similar to 2N3905 or 2N3906

QUAD DUAL-IN-LINE SILICON COMPLEMENTARY PAIR TRANSISTOR



MAXIMUM RATINGS

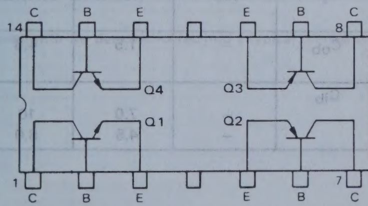
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
		Each Transistor	Four Transistors Equal Power	
Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	500 4.0	900 7.2	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	825 6.7	2400 19.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

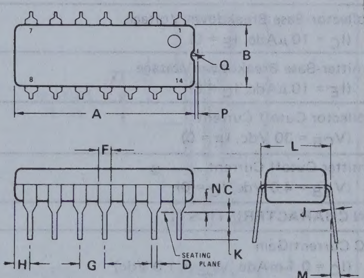
(1) Second Breakdown occurs at power levels greater than 3 times the power dissipation rating.

THERMAL CHARACTERISTICS

Characteristic		Junction to Case	Junction to Ambient	Unit
Thermal Resistance	Each Die	151	250	°C/W
	Effective, 4 Die	52	134	°C/W
Coupling Factors	Q1-Q4 or Q2-Q3	34	70	%
	Q1-Q2 or Q3-Q4	2.0	26	%

CONNECTION DIAGRAM





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	18.80	0.715	0.740
B	6.10	6.60	0.240	0.260
C	4.06	4.57	0.160	0.180
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.32	1.83	0.052	0.072
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.37	7.87	0.290	0.310
M	–	10°	–	10°
N	0.51	1.02	0.020	0.040
P	0.13	0.38	0.005	0.015
Q	0.51	0.76	0.020	0.030

CASE 646

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1. If significant power is to be dissipated in two die, die at the opposite ends of the package should be used so that lowest possible junction temperatures will result.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 50 70	 70 120 160	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.1	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.75	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	1.5	4.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz) PNP NPN	C_{ib}	 – –	 7.0 4.5	 10 8.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

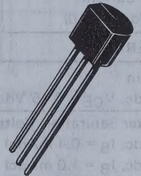
MPS404 (SILICON)
MPS404A

PNP SILICON CHOPPER TRANSISTORS

PNP SILICON ANNULAR TRANSISTORS

. . . plastic encapsulated package designed for medium-speed chopper applications in industrial and computer equipment. Intended for operation in applications replacing the 2N404 and 2N404A transistors.

- High Emitter-Base Breakdown Voltage –
  BV_{EBO} = 12 Vdc (Min) – MPS404
  25 Vdc (Min) – MPS404A
  50 Vdc (Typ) – MPS404, MPS404A
- Full Design Curves



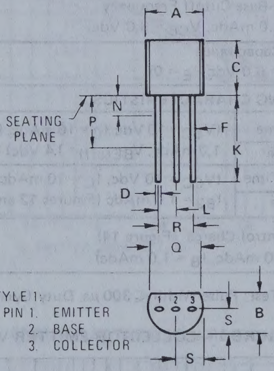
MAXIMUM RATINGS

Rating	Symbol	MPS404	MPS404A	Unit
Collector-Emitter Voltage	V_{CEO}	24	35	Vdc
Collector-Base Voltage	V_{CB}	25	40	Vdc
Emitter-Base Voltage	V_{EB}	12	25	Vdc
Collector Current – Continuous	I_C	150		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8		mW mW/°C
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0) MPS404 MPS404A	BV_{CEO}	24 35	– –	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) MPS404 MPS404A	BV_{CBO}	25 40	– –	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0) MPS404 MPS404A	BV_{EBO}	12 25	50 50	– –	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.15 Vdc)	h_{FE}	30	100	400	–
Collector-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	– –	0.1 0.12	0.15 0.20	Vdc
Base-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc) (I_C = 24 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	– –	0.7 0.74	0.85 1.0	Vdc
DYNAMIC CHARACTERISTICS					
Common-Base Cutoff Frequency (I_C = 1.0 mAdc, V_{CB} = 6.0 Vdc)	$f_{\alpha b}$	4.0	–	–	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0)	C_{ob}	–	6.8	20	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc, $V_{BE(off)}$ = 1.4 Vdc) (Fig. 11,13)	t_d	–	43	–	ns
Rise Time	t_r	–	180	–	ns
Storage Time (V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc (Figures 12 and 13)	t_s	–	675	–	ns
Fall Time	t_f	–	160	–	ns
Total Control Charge (Figure 14) (I_C = 10 mAdc, I_B = 1.0 mAdc)	Q_S	–	–	1400	pC

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – COLLECTOR-EMITTER VOLTAGE

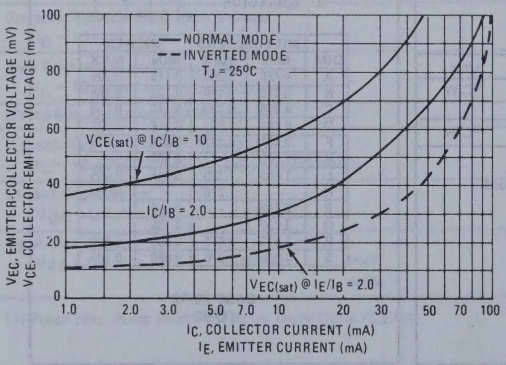
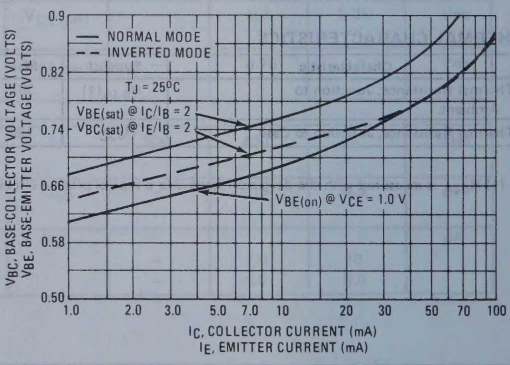


FIGURE 2 – BASE "ON" VOLTAGE



NORMAL MODE

FIGURE 3 – DC CURRENT GAIN @ V_{CE} = 0.15 Vdc

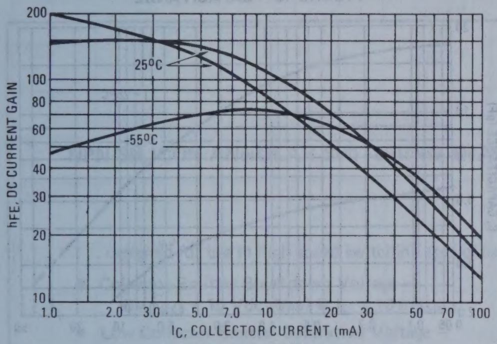


FIGURE 5 – DC CURRENT GAIN @ V_{CE} = 1.0 Vdc

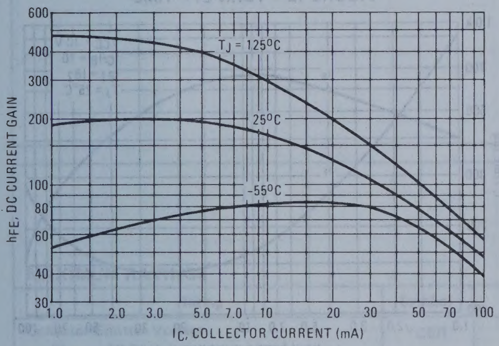
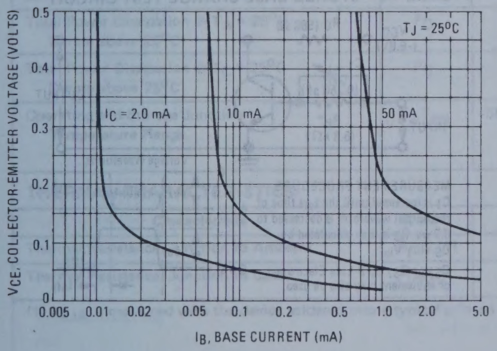


FIGURE 7 – COLLECTOR SATURATION REGION



INVERTED MODE

FIGURE 4 – DC CURRENT GAIN @ V_{EC} = 0.15 Vdc

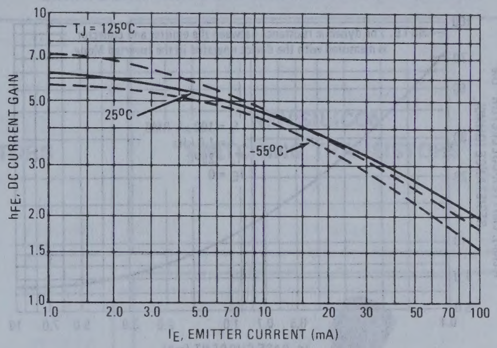


FIGURE 6 – DC CURRENT GAIN @ V_{EC} = 1.0 Vdc

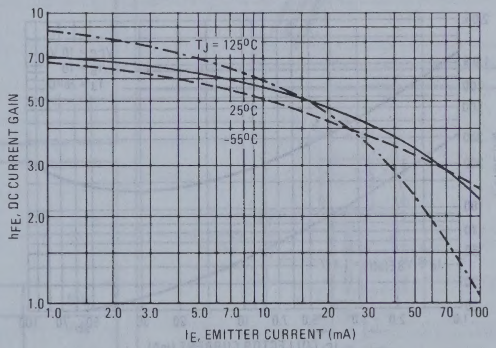


FIGURE 8 – EMITTER SATURATION REGION

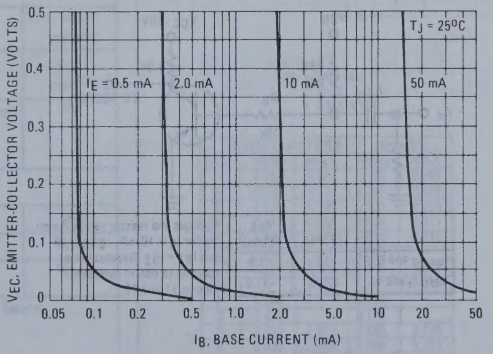


FIGURE 9 – EMITTER-COLLECTOR "ON" RESISTANCE

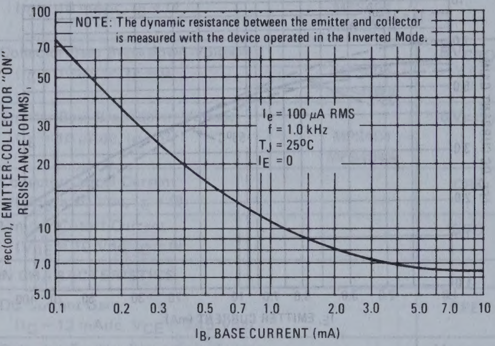


FIGURE 10 – CAPACITANCE

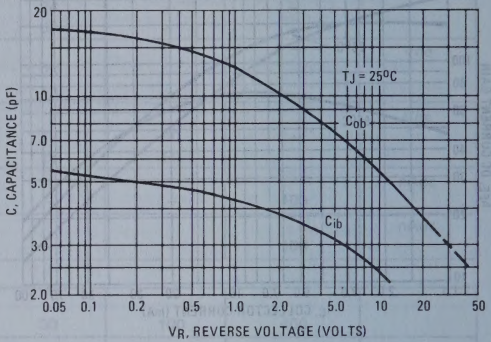


FIGURE 11 – TURN-ON TIME

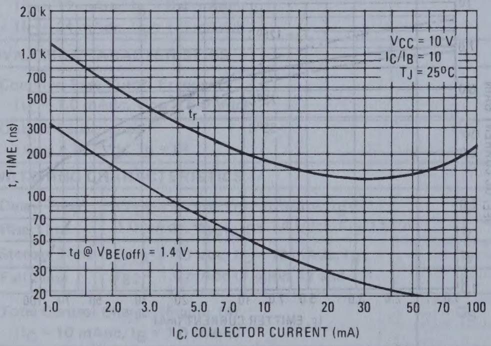


FIGURE 12 – TURN-OFF TIME

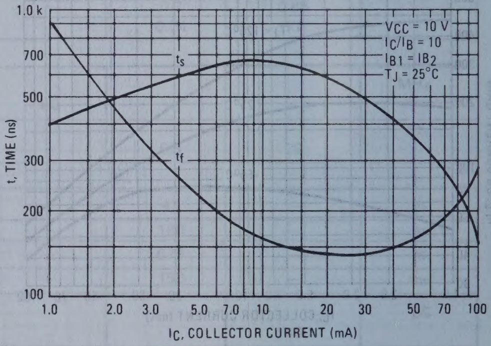
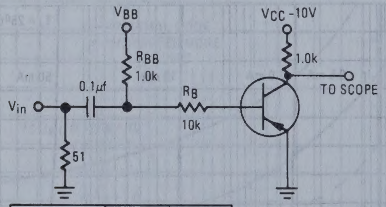


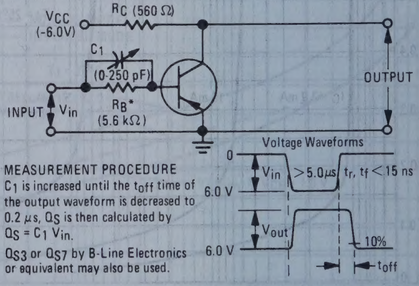
FIGURE 13 – SWITCHING TIME TEST CIRCUIT


VBB
VCC -10V
RBB
1.0k
1.0k
0.1μf
Vin
RB
10k
TO SCOPE
51

	Vin (Volts)	VBB (Volts)
ton, td and tr	-12	+1.4
toff, ts and tf	+20.6	-11.6

Voltages and resistor values shown are for I_C = 10 mA, I_C/I_B = 10 and $I_{B1} = I_{B2}$. Resistor values changed to obtain curves in Figures 11 and 12.

FIGURE 14 – STORED BASE CHARGE TEST CIRCUIT


VCC (-6.0V)
RC (560 Ω)
C1
(0-250 pF)
RB*
(5.6 kΩ)
INPUT
Vin
OUTPUT
Voltage Waveforms
0
Vin
>5.0μs
tr, tf < 15 ns
6.0 V
Vout
10%
6.0 V
toff

MEASUREMENT PROCEDURE

C_1 is increased until the t_{off} time of the output waveform is decreased to 0.2 μs, Q_S is then calculated by $Q_S = C_1 V_{in}$.

Q_{S3} or Q_{S7} by B-Line Electronics or equivalent may also be used.

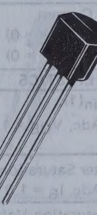
MPS706, MPS706A (SILICON)

NPN SILICON ANNULAR SWITCHING TRANSISTORS

. . . designed for use in high-speed switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 15 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Typ) @ I_C = 10 mAdc
- Fast Switching Times @ I_C = 10 mAdc
  - t_{on} = 40 ns (Max)
  - t_{off} = 75 ns (Max)

NPN SILICON SWITCHING TRANSISTORS



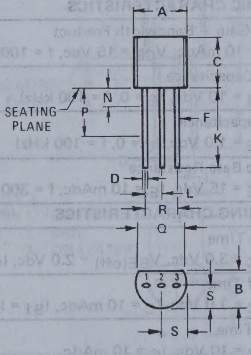
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	15	–	–	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, R_{BE} = 10 Ohms)		BV_{CER}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector-Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 15 Vdc, I_E = 0)	MPS706		–	–	0.5	
(V_{CB} = 25 Vdc, I_E = 0)	MPS706A		–	–	10	
Collector Cutoff Current (V_{CE} = 20 Vdc, R_{BE} = 100 kHz)	MPS706A	I_{CER}	–	–	10	μAdc
Emitter Cutoff Current		I_{EBO}				μAdc
(V_{BE} = 3.0 Vdc, I_C = 0)	MPS706		–	–	10	
(V_{BE} = 5.0 Vdc, I_C = 0)	MPS706A		–	–	10	
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MPS706		20	50	–	
	MPS706A		20	45	60	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.3	0.6	Vdc
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS706		–	0.8	0.9	
	MPS706A		0.7	0.8	0.9	
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	200	600	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	MPS706	C_{ob}	–	1.5	6.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	3.4	–	pF
Extrinsic Base Resistance (V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 300 MHz)		r_b	–	–	50	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	(Figure 1)	t_{on}	–	35	40	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 3.0 mAdc)	(Figure 1)	t_{off}	–	55	75	ns
Storage Time	MPS706A	t_s	–	20	25	ns
(V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	MPS706		–	20	60	
	(Figure 2)					

(1) Pulse Test: Pulse Width ⩽12 ns, Duty Cycle ⩽2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

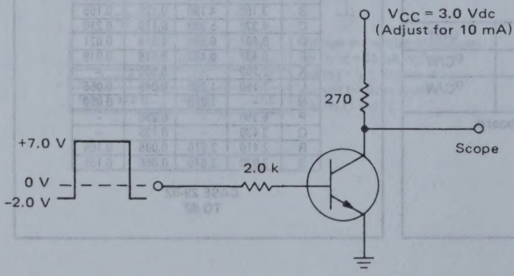
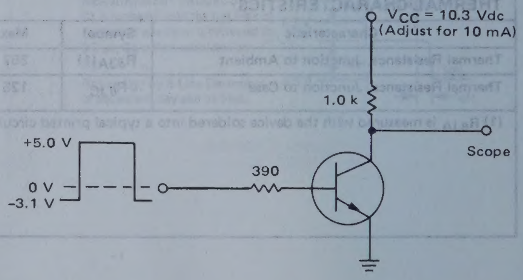


FIGURE 2 – STORAGE TIME TEST CIRCUIT



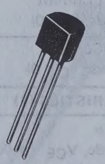
MPS708 (SILICON)

NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in high-speed switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CER} = 20 Vdc (Min) @ I_C = 30 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.21 Vdc (Typ) @ I_C = 10 mAdc
- MPS708 Electrically Similar to 2N708 — TO-18 Package

NPN SILICON SWITCHING TRANSISTOR



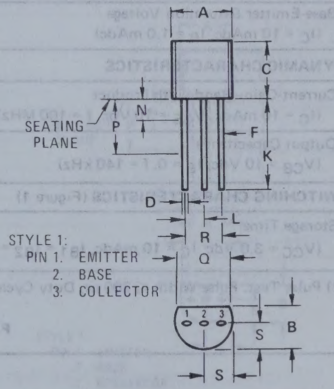
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

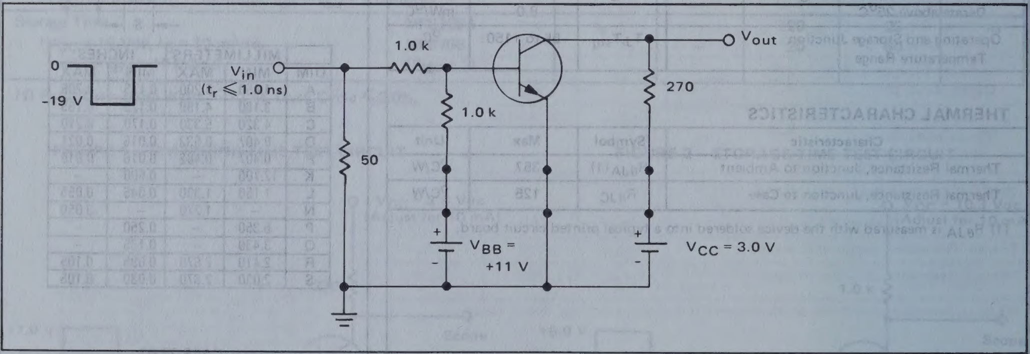
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, R_{BE} = 10 Ohms)	BV_{CER}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	25	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	80	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)		15	35	–	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	50	120	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.21	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.68	0.7	0.78	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	600	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	2.4	6.0	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Storage Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	–	14	25	ns

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



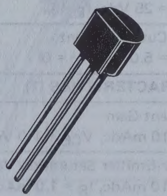
MPS753 (SILICON)

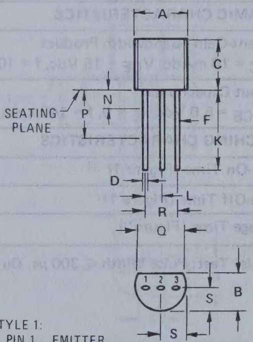
NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in medium-voltage high-speed switching applications.

- Collector-Emitter Breakdown Voltage – BV_{CER} = 20 Vdc (Min) @ I_C = 10 mAdc
- High Current-Gain–Bandwidth Product – f_T = 600 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Times
  - t_{on} = 40 ns (Max)
  - t_{off} = 75 ns (Max)

NPN SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, R_{BE} = 10 Ohms)	BV_{CER}	20	–	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, R_{BE} = 100 k Ohms)	I_{CER}	–	–	10	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	 – –	 – –	 0.5 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	100	120	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.3	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.8	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	200	600	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	1.5	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	–	30	40	ns
Turn-Off Time (Figure 1)	t_{off}	–	60	75	ns
Storage Time (Figure 2)	t_s	–	30	35	ns

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

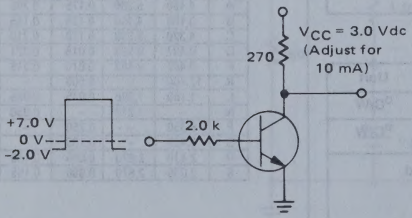
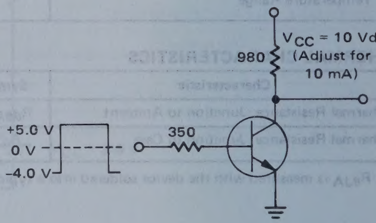


FIGURE 2 – STORAGE TIME TEST CIRCUIT



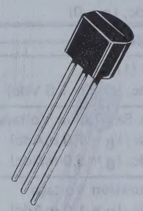
MPS834 (SILICON)

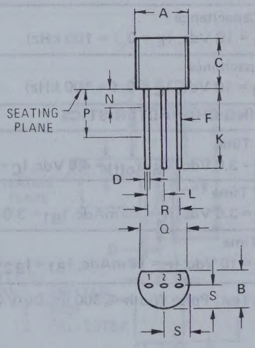
NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in high-speed switching applications.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 30 Vdc (Min) @ I_C = 10 mAdc
- High Current-Gain—Bandwidth Product
  f_T = 600 MHz (Typ) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 10 mAdc
- Fast Switching Times @ I_C = 10 mAdc
  t_{on} = 16 ns (Max)
  t_{off} = 30 ns (Max)
- Excellent Predriver for N-MOS clock drivers.
  Use with 2N5845 and MPS3638 Active Pull-Up and Pull-Down Transistors.

NPN SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $V_{BE} = 0$)	I_{CES}	–	–	10	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	–	–	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 10$ mAdc, $V_{CE} = 1.0$ Vdc)	h_{FE}	25	–	–	–
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc) ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc) (1)	$V_{CE(sat)}$	 – –	 0.2 0.3	 0.25 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{BE(sat)}$	–	0.7	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	350	600	–	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	1.5	4.0	pF
Input Capacitance ($V_{EB} = 10$ Vdc, $I_C = 0$, f = 100 kHz)	C_{ib}	–	3.4	–	pF
SWITCHING CHARACTERISTICS					
Turn-On Time See Figure 1 ($V_{CC} = 3.0$ Vdc, $V_{BE(off)} = 4.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc)	t_{on}	–	12	16	ns
Turn-Off Time ($V_{CC} = 3.0$ Vdc, $I_C = 10$ mAdc, $I_{B1} = 3.0$ mAdc) See Figure 1	t_{off}	–	25	30	ns
Storage Time ($V_{CC} = 10$ Vdc, $I_C = 10$ mAdc, $I_{B1} = I_{B2} = 10$ mAdc) See Figure 2	t_s	–	18	25	ns

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

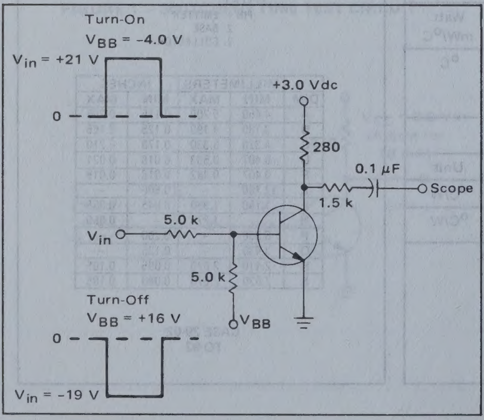
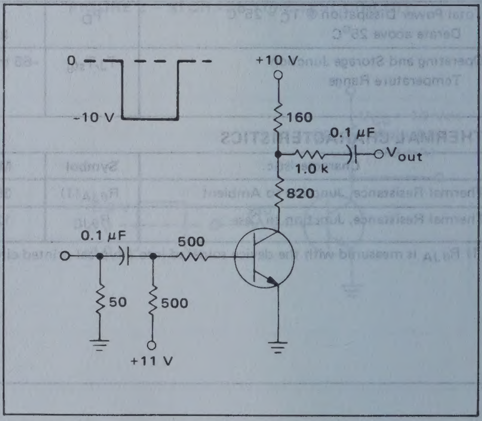


FIGURE 2 – STORAGE TIME TEST CIRCUIT



MPS835 (SILICON)

NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for high-speed saturated switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 20 Vdc (Min) @ I_C = 10 mAdc
- High Current-Gain—Bandwidth Product — f_T = 600 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Times — t_{on} = 15 ns (Max) t_{off} = 30 ns (Max)

MAXIMUM RATINGS

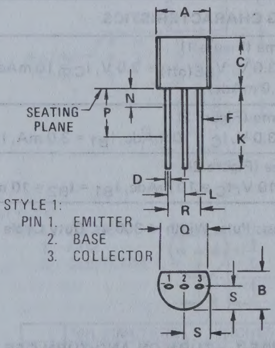
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector-Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON SWITCHING TRANSISTOR



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	–	–	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	35	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.20	0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.78	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	300	600	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	1.5	4.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (V_{CC} = 3.0 V, $V_{BE(off)}$ = 2.0 V, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{on}	–	15	20	ns
Turn-Off Time (Figure 2) (V_{CC} = 3.0 V, I_C = 10 mAdc, I_{B1} = 3.0 mA, I_{B2} = 1.0 mAdc)	t_{off}	–	30	35	ns
Storage Time (Figure 2) (V_{CC} = 10 V, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	–	28	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

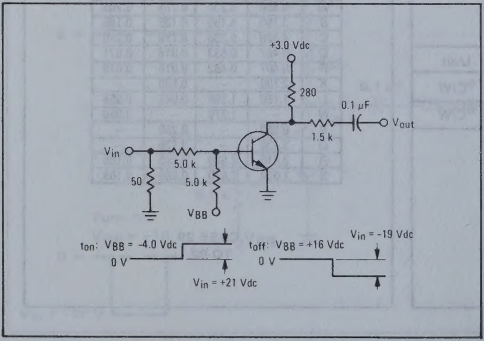
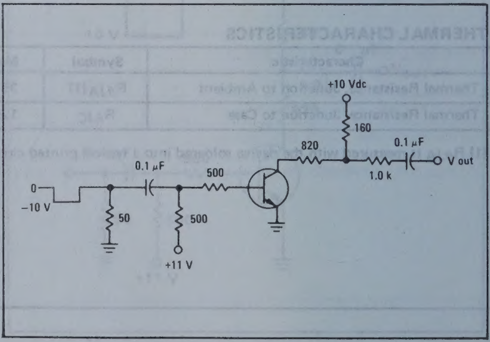

+3.0 Vdc
280
0.1 μF
V_out
1.5 k
V_in
5.0 k
50
5.0 k
V_BB
t_on: V_BB = -4.0 Vdc
0 V
V_in = +21 Vdc
t_off: V_BB = +16 Vdc
0 V
V_in = -19 Vdc

FIGURE 2 – STORAGE TIME TEST CIRCUIT


+10 Vdc
160
820
0.1 μF
V out
1.0 k
0.1 μF
500
0
-10 V
50
500
+11 V

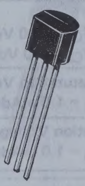
MPS918 (SILICON)
MPS3563

NPN SILICON ANNULAR TRANSISTORS

. . . designed for VHF/UHF low-level amplifier, and oscillator applications.

- One-Piece, Injection-Molded Plastic Unibloc Package for High Reliability
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 10 mAdc

NPN SILICON
AMPLIFIER
TRANSISTORS



MAXIMUM RATINGS

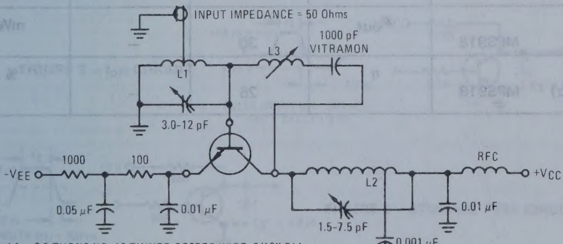
Rating	Symbol	MPS918	MPS3563	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CB}	30	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	2.0	Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the deviced soldered into a typical printed circuit board.

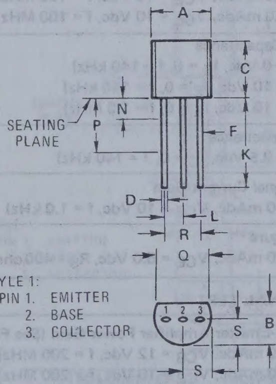
FIGURE 1 — 200 MHz POWER GAIN TEST CIRCUIT


INPUT IMPEDANCE = 50 Ohms
1000 pF
VITRAMON
L3
L1
3.0-12 pF
1000
100
-VEE
RFC
+VCC
L2
0.05 µF
0.01 µF
0.01 µF
1.5-7.5 pF
0.001 µF
OUTPUT IMPEDANCE = 50 Ohms

L1 – 3.5 TURNS NO. 16 TINNED COPPER WIRE; 5/16" DIA; 7/16" LONG TURNS RATIO ≈ 4 to 2

L2 – 8 TURNS NO. 16 TINNED COPPER WIRE; 1/8" DIA; 7/8" LONG TURNS RATIO ≈ 8 TO 1

L3 – MILLER #4303 (0.4-0.65 µH)


A
C
N
P
SEATING PLANE
F
K
D
L
R
Q
1
2
3
B
S
S

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(2)	BV_{CEO}			Vdc
(I_C = 3.0 mAdc, I_B = 0) MPS918		15	–	
MPS3563		12	–	
Collector-Base Breakdown Voltage	BV_{CBO}			Vdc
(I_C = 1.0 μAdc, I_E = 0) MPS918		30	–	
(I_C = 100 μAdc, I_E = 0) MPS3563		30	–	
Emitter-Base Breakdown Voltage	BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0) MPS918		3.0	–	
MPS3563		2.0	–	
Collector Cutoff Current	I_{CBO}			nAdc
(V_{CB} = 15 Vdc, I_E = 0) MPS918		–	10	
MPS3563		–	50	
ON CHARACTERISTICS				
DC Current Gain(2)	h_{FE}			–
(I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) MPS918		20	–	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc) MPS3563		20	200	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc) MPS918		–	0.4	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc) MPS918		–	1.0	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product(2)	f_T			MHz
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) MPS918		600	–	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) MPS3563		600	1500	
Output Capacitance	C_{ob}			pF
(V_{CB} = 0 Vdc, I_E = 0, f = 140 kHz) MPS918		–	3.0	
(V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) MPS918		–	1.7	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) MPS3563		–	1.7	
Input Capacitance	C_{ib}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz) MPS918		–	2.0	
Small-Signal Current Gain	h_{fe}			–
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MPS3563		20	250	
Noise Figure	NF			dB
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz) MPS918		–	6.0	
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (See Figure 1)	G_{pe}			dB
(I_C = 6.0 mAdc, V_{CB} = 12 Vdc, f = 200 MHz) MPS918		15	–	
(I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz) MPS3563		14	–	
($G_{fd} + G_{re} < -20$ dB)				
Power Output	P_{out}			mW
(I_C = 8.0 mAdc, V_{CB} = 15 Vdc, f = 500 MHz) MPS918		30	–	
Oscillator Collector Efficiency	η			%
(I_C = 8.0 mAdc, V_{CB} = 15 Vdc, P_{out} = 30 mW, f = 500 MHz) MPS918		25	–	

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS2369 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for use in high-speed, low-current switching applications.

- Low Output Capacity
  $C_{ob} = 4.0$ pF @ $V_{CB} = 5.0$ Vdc
- Fast Switching Time @ $I_C = 10$ mAdc
  $t_{on} = 12\ \mu s$ (Max)
  $t_{off} = 18$ ns (Max)
- High Current-Gain—Bandwidth Product
  $f_T = 500$ MHz @ $I_C = 10$ mAdc

NPN SILICON
SWITCHING
TRANSISTOR

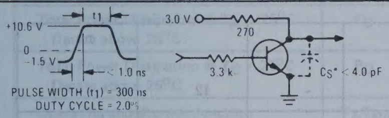
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

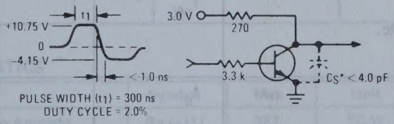
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



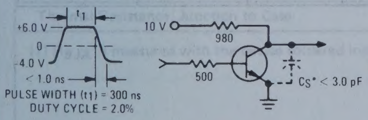
t1
+10.6 V
0
-1.5 V
< 1.0 ns
PULSE WIDTH (t1) = 300 ns
DUTY CYCLE = 2.0%
3.0 V
270
3.3 k
CS* < 4.0 pF

FIGURE 1 – t_{on} CIRCUIT

FIGURE 2 – t_{off} CIRCUIT



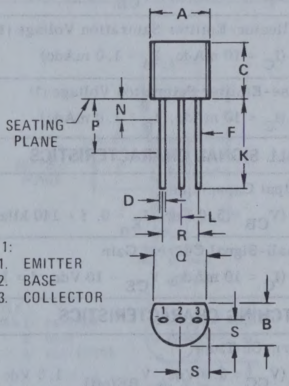
t1
+10.75 V
0
-4.15 V
< 1.0 ns
PULSE WIDTH (t1) = 300 ns
DUTY CYCLE = 2.0%
3.0 V
270
3.3 k
CS* < 4.0 pF



t1
+6.0 V
0
-4.0 V
< 1.0 ns
PULSE WIDTH (t1) = 300 ns
DUTY CYCLE = 2.0%
10 V
980
500
CS* < 3.0 pF

FIGURE 3 – STORAGE TEST CIRCUIT

*Total shunt capacitance of test jig and connectors.



A
C
N
P
SEATING PLANE
F
K
D
L
R
Q
1
2
3
S
B
S

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 µAdc, V_{BE} = 0)	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	 - -	 0.4 30	µAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 20 20	 120 - -	-
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.85	Vdc
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	4.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	$\|h_{fe}\|$	5.0	-	-
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Figure 1)	t_{on}	-	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Figure 2)	t_{off}	-	18	ns
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc) (Figure 3)	t_s	-	13	ns

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle = 2.0%

MPS2712 (SILICON)
MPS2716

NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for use as a general-purpose amplifier.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 18 Vdc (Min) @ I_C = 1.0 mAdc
- Low Output Capacitance —
  C_{ob} = 2.0 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON
AMPLIFIER
TRANSISTORS

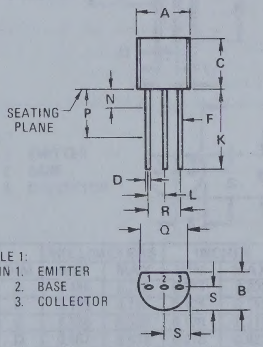
MAXIMUM RATINGS

Rating	Symbol	MPS2712	MPS2716	Unit
Collector-Emitter Voltage	V_{CEO}	18		Vdc
Collector-Base Voltage	V_{CB}	18		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	100	25	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.6		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^{o}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	18	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 18$ Vdc, $I_E = 0$) ($V_{CB} = 18$ Vdc, $I_E = 0$, $T_A = 100^{o}C$)	I_{CBO}	–	–	0.5 15	µAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)	I_{EBO}	–	–	0.5	µAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 2.0$ mAdc, $V_{CE} = 4.5$ Vdc) MPS2712, MPS2716	h_{FE}	75	150	225	–
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz) MPS2712 MPS2716	C_{ob}	– –	2.0 2.0	12 5.0	pF

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle ⩽2.0%.

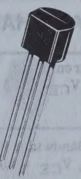
MPS2714 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for use in low-level switching applications.

- Low Output Capacitance —
  C_{ob} = 2.5 pF (Typ) @ V_{CB} = 10 Vdc
- Fast Switching Time @ I_C = 10 mAdc
  t_s = 12 ns (Typ)
- High Current-Gain—Bandwidth Product
  f_T = 250 MHz (Typ) @ I_C = 10 mAdc

NPN SILICON SWITCHING TRANSISTOR



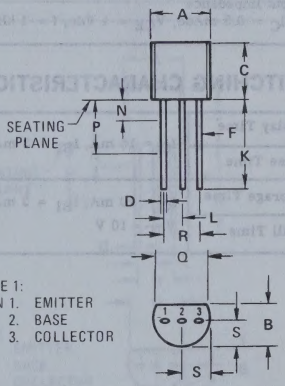
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc)		h_{FE}	75	150	225	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{CE(sat)}$	—	0.16	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{BE(sat)}$	0.6	0.75	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS						
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc, f = 1 kHz)		h_{fe}	80	—	300	—
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	—	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	2.5	—	pF
Input Impedance (I_C = 0.5 mAdc, V_{CE} = 1 Vdc, f = 1 kHz)		h_{ie}	—	3000	—	ohms
SWITCHING CHARACTERISTICS						
Delay Time	I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 10 V	t_d	—	7.0	—	ns
Rise Time		t_r	—	6.0	—	ns
Storage Time	I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1 mA, V_{CC} = 10 V	t_s	—	12	—	ns
Fall Time		t_f	—	9.0	—	ns

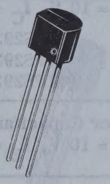
MPS2923 thru MPS2925 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for use in medium-speed general-purpose amplifier and oscillator applications.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 25 Vdc
- Small Signal Current Gain —
  h_{fe} = 90-180 MPS2923
  150-300 MPS2924
  235-470 MPS2925

NPN SILICON SWITCHING TRANSISTOR



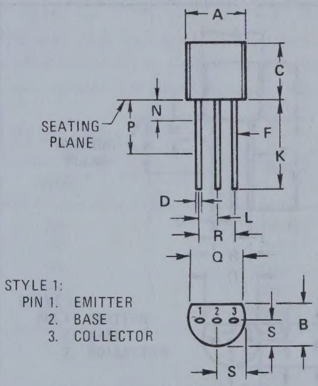
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $V_{CB} = 25$ V, $I_E = 0$ $V_{CB} = 25$ V, $I_E = 0$, $T_A = 100°C$	I_{CBO}	– –	0.5 15	µA µA
Emitter Cutoff Current $V_{EB} = 5$ V	I_{EBO}	–	0.5	µA
Small Signal Current Gain (f = 1 kHz) $V_{CE} = 10$ V, $I_C = 2$ mA	h_{fe}			–
MPS2923		90	180	
MPS2924		150	300	
MPS2925		235	470	
Collector Capacitance $V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz	C_{ob}	–	12	pF

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: $P_D = 1.0$ W @ $T_C = 25^oC$, Derate above 25^oC – 8.0 mW/^oC, $T_J = -65$ to $+150^oC$, $\theta_{JC} = 125^oC/W$.

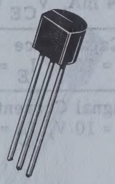
MPS2926 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for use in amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 18 Vdc
- Small-Signal Current Gain — h_{fe} = 35-470

NPN SILICON
AMPLIFIER
TRANSISTOR



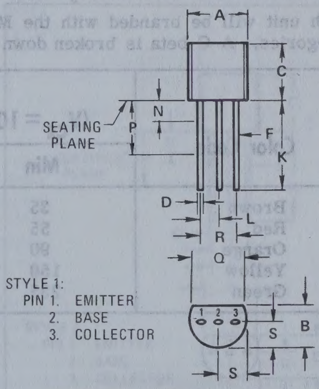
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0) (V_{CB} = 18 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	— —	— —	0.5 15	μA
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μA
Current Gain — Bandwidth Product (I_C = 4 mA, V_{CE} = 5 V)	f_T	—	300	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}	—	—	3.5	pF
Small Signal Current Gain (V_{CE} = 10 V, I_C = 2 mA, f = 1 kHz)	h_{fe}	35	—	470	—

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125° C/W.

Each unit will be branded with the MPS2926 type and also by color code to identify the different A-C beta categories. A-C beta is broken down into five groups, and typical values of DC beta are listed for guidance.

Color Code	h_{fe} (V_{CE} = 10 V, I_C = 2 mA, f = 1 KHz)		h_{FE} (V_{CE} = 4.5 V, I_C = 2 mA)
	Min	Max	Typ
Brown	35	70	36
Red	55	110	62
Orange	90	180	115
Yellow	150	300	155
Green	235	470	215

MPS3390 (SILICON)
thru
MPS3398

NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for use in general-purpose and high-gain amplifier or driver applications.

- Collector-Emitter Breakdown Voltage – BV_{CEO} = 25 Vdc (Min) @ I_C = 1.0 mAdc
- DC Current Gain Specified at 2.0 mAdc –
  h_{FE} = 400-800 – MPS3390
  250-500 – MPS3391
  150-300 – MPS3392
  90-180 – MPS3393
  55-110 – MPS3394
  150-500 – MPS3395
  90-500 – MPS3396
  55-500 – MPS3397
  55-800 – MPS3398

MAXIMUM RATINGS

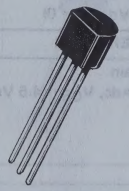
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector-Current – Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipaton @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

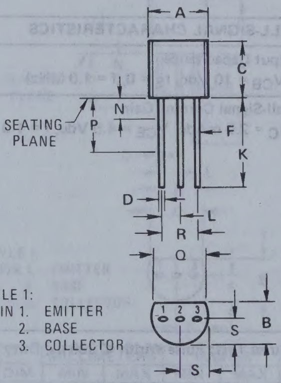
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON AMPLIFIER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	25	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 μAdc, I_E = 0)		BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0)		I_{CBO}	–	–	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	–	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 2.0 mAdc, V_{CE} = 4.5 Vdc)	MPS3390		400	–	800	
	MPS3391		250	–	500	
	MPS3392		150	–	300	
	MPS3393		90	–	180	
	MPS3394		55	80	110	
	MPS3395		150	–	500	
	MPS3396		90	–	500	
	MPS3397		55	–	500	
	MPS3398		55	–	800	
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	2.0	10	pF
Small-Signal Current Gain		h_{fe}				–
(I_C = 2.0 mAdc, V_{CE} = 4.5 Vdc, f = 1.0 kHz)						
	MPS3390		400	–	1250	
	MPS3391		250	–	800	
	MPS3392		150		500	
	MPS3393		90		400	
	MPS3394		55		300	
	MPS3395		150		800	
	MPS3396		90	–	800	
	MPS3397		55	–	800	
	MPS3398		55	–	1250	

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

MPS3563 (SILICON)

For Specifications, See MPS918 Data.

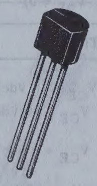
MPS3638 (SILICON)
MPS3638A

NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-current switching applications.

- Collector-Emitter Sustaining Voltage — $V_{CEO(sus)}$ = 25 Vdc (Min)
- DC Current Gain Specified — 1.0 mAdc to 300 mAdc
- Fast Switching Time @ I_C = 30 mAdc t_s = 140 ns (Max)
- Current-Gain—Bandwidth Product — f_T = 150 MHz (Min) @ I_C = 50 mAdc MPS3638A
- Electrically Similar to 2N3638,A

NPN SILICON SWITCHING TRANSISTORS



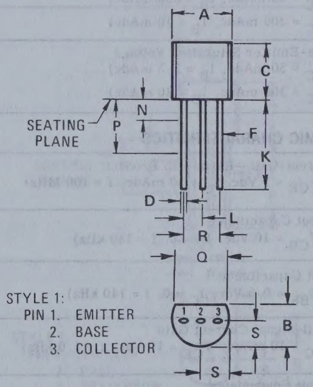
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	25	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0) (V_{CE} = 15 Vdc, V_{BE} = 0, T_A = +65°C)	I_{CES}	- -	0.035 2.0	μAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_B	-	0.035	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 1 mAdc, V_{CE} = 10 Vdc) MPS3638A (I_C = 10 mAdc, V_{CE} = 10 Vdc) MPS3638 MPS3638A (I_C = 50 mAdc, V_{CE} = 1 Vdc) MPS3638 MPS3638A (I_C = 300 mAdc, V_{CE} = 2 Vdc) MPS3638 MPS3638A	h_{FE}	80 20 100 30 100 20 20	- - - - - - -	-
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 2.5 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{CE(sat)}$	- -	0.25 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 2.5 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{BE(sat)}$	- 0.80	1.1 2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (V_{CE} = 3 Vdc, I_C = 50 mAdc, f = 100 MHz) MPS3638 MPS3638A	f_T	100 150	- -	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) MPS3638 MPS3638A	C_{ob}	- -	20 10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz) MPS3638 MPS3638A	C_{ib}	- -	65 25	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MPS3638 MPS3638A	h_{fe}	25 100	180 -	-
Output Conductance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	-	1.2	mmhos
Input Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MPS3638 MPS3638A	h_{ie}	- -	1500 2000	Ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) MPS3638 MPS3638A	h_{re}	- -	26 15	$X10^{-4}$

SWITCHING CHARACTERISTICS

Delay Time	V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc, $V_{BE(off)}$ = 3.1 Vdc	t_d	-	20	ns
Rise Time		t_r	-	70	ns
Storage Time	V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_s	-	140	ns
Fall Time		t_f	-	70	ns
Turn-On Time	I_C = 300 mAdc, I_{B1} = 30 mAdc	t_{on}	-	75	ns
Turn-Off Time	I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_{off}	-	170	ns

(1) **Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%**

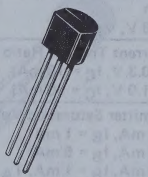
MPS3639 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in low-current, high-speed switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CES} = 6.0 Vdc (Min)
- Fast Switching Time @ I_C = 50 mAdc
  t_{on} = 25 ns (Max)
  t_{off} = 25 ns (Max)
- Low Output Capacitance — C_{ob} = 3.5 pF (Max) @ V_{CB} = 5.0 Vdc

PNP SILICON
SWITCHING
TRANSISTOR



MAXIMUM RATINGS

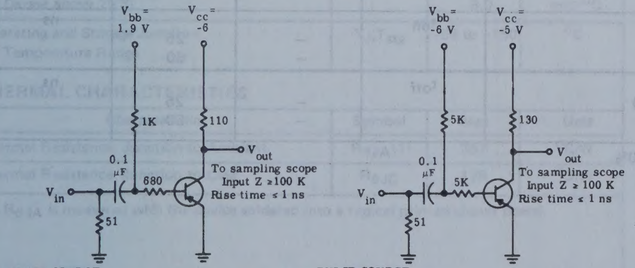
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	Vdc
Collector-Base Voltage	V_{CB}	6.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

SWITCHING TIME TEST CIRCUITS

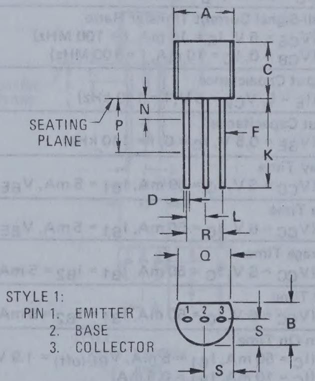

V_{bb} = 1.9 V
V_{cc} = -6
1K
110
V_{out}
To sampling scope
Input Z ≥100 K
Rise time ≤ 1 ns
0.1 μF
680
V_{in}
51
V_{bb} = -6 V
V_{cc} = -5 V
5K
130
V_{out}
To sampling scope
Input Z ≥ 100 K
Rise time ≤ 1 ns
0.1 μF
5K
V_{in}
51

PULSE SOURCE
Rise time ≤ 1 ns
PW ≥100 ns
Z_{in} = 50Ω
Fall time ≤1 ns

NOTES: (1) Collector Current = 50 mA
(2) Turn-On and Turn-Off Base Currents = 5 mA

PULSE SOURCE
Rise time ≤ 1 ns
PW ≥ 200 ns
Z_{in} = 50Ω
Fall time ≤1

NOTES: (1) Collector Current = 10 mA
(2) Turn-On and Turn-Off Base Currents = 0.5 mA


A
C
N
SEATING PLANE
P
F
K
D
L
R
Q
1
2
3
S
B
S

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage (1) (I_B = 0, I_C = 10 mA)	$V_{CEO(sus)}$	6.0	–	V
Collector-Emitter Breakdown Voltage (I_C = 100 μA, V_{BE} = 0)	BV_{CES}	6.0	–	V
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)	BV_{CBO}	6.0	–	V
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	BV_{EBO}	4.0	–	V
Collector Cutoff Current (V_{CE} = 3 V, V_{EB} = 0) (V_{CE} = 3 V, V_{EB} = 0, T_A = +65°C)	I_{CES}	 – –	 0.01 1.0	μA
Base Current (V_{CE} = 3 V, V_{EB} = 0)	I_B	–	10	nA
Forward Current Transfer Ratio (1) (V_{CE} = 0.3 V, I_C = 10 mA) (V_{CE} = 1.0 V, I_C = 50 mA)	h_{FE}	 30 20	 120 –	–
Collector-Emitter Saturation Voltage (1) (I_C = 10 mA, I_B = 1 mA) (I_C = 50 mA, I_B = 5 mA) (I_C = 10 mA, I_B = 1 mA, T_A = +65°C)	$V_{CE(sat)}$	 – – –	 0.16 0.5 0.23	V
Base-Emitter Saturation Voltage (1) (I_C = 10 mA, I_B = 0.5 mA) (I_C = 10 mA, I_B = 1 mA) (I_C = 50 mA, I_B = 5 mA)	$V_{BE(sat)}$	 0.75 0.8 –	 0.95 1.0 1.5	V
Small-Signal Current Transfer Ratio (V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz) (V_{CB} = 0, I_C = 10 mA, f = 100 MHz)	h_{fe}	 5.0 3.0	 – –	–
Output Capacitance (I_E = 0, V_{CB} = 5 V, f = 140 kHz)	C_{ob}	–	3.5	pF
Input Capacitance (V_{BE} = 0.5 V, I_C = 0, f = 140 kHz)	C_{ib}	–	3.5	pF
Delay Time (V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA, $V_{BE(off)}$ = 1.9 V)	t_d	–	10	ns
Rise Time (V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA, $V_{BE(off)}$ = 1.9 V)	t_r	–	30	ns
Storage Time (V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA)	t_s	–	20	ns
Fall Time (V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA)	t_f		12	ns
Turn-On Time (I_C = 50 mA, I_{B1} = 5 mA, $V_{BE(off)}$ = 1.9 V) (I_C = 10 mA, I_{B1} = 0.5 mA)	t_{on}	 – –	 25 60	ns
Turn-Off Time (I_C = 50 mA, $V_{BE(off)}$ = 1.9 V, I_{B1} = I_{B2} = 5 mA) (I_C = 10 mA, I_{B1} = I_{B2} = 0.5 mA)	t_{off}	 – –	 25 60	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

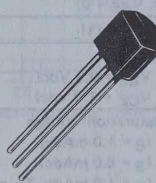
MPS3640 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, low-level switching applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.2 Vdc @ I_C = 10 mAdc
- Output Capacitance — C_{ob} = 3.5 pF (Max) @ V_{CB} = 5.0 Vdc
- Fast Switching Time @ I_C = 50 mAdc
  t_{on} = 25 ns (Max)
  t_{off} = 35 ns (Max)

PNP SILICON SWITCHING TRANSISTOR



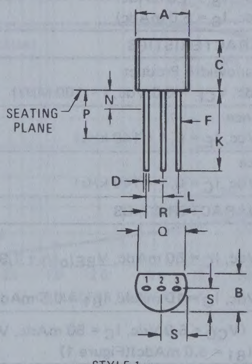
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	80	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

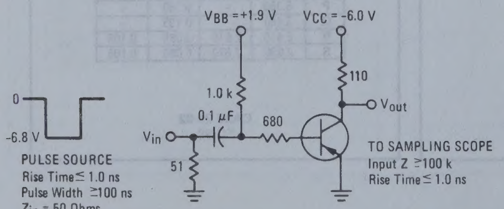
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

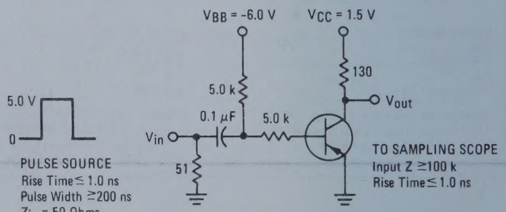
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	12	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	 – –	 0.01 1.0	μAdc
Reverse Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	–	10	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 20	 120 –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 65°C)	$V_{CE(sat)}$	 – – –	 0.2 0.6 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	 0.75 0.8 –	 0.95 1.0 1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	500	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	3.5	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc) (Figure 1) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 0.5 mAdc) (Figure 2)	t_{on}	 – –	 25 60	ns
Delay Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, $V_{BE(off)}$ = 1.9 Vdc, I_{B1} = 5.0 mAdc)(Figure 1)	t_d	–	10	ns
Rise Time	t_r	–	30	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = I_{B1} = I_{B2} = 5.0 mAdc) (Figure 1) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc) (Figure 2)	t_{off}	 – –	 35 75	ns
Storage Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc) (Figure 1)	t_s	–	20	ns
Fall Time	t_f	–	12	ns

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.



V_BB = +1.9 V
V_CC = -6.0 V
0
-6.8 V
PULSE SOURCE
Rise Time ≤ 1.0 ns
Pulse Width ≥100 ns
Z_in = 50 Ohms
Fall Time ≤ 1.0 ns
1.0 k
0.1 μF
680
110
V_out
V_in
51
TO SAMPLING SCOPE
Input Z ≥100 k
Rise Time ≤ 1.0 ns

NOTES: Collector Current = 50 mA, Turn-On and Turn-Off Time Base Currents = 5.0 mA.



V_BB = -6.0 V
V_CC = 1.5 V
5.0 V
0
PULSE SOURCE
Rise Time ≤ 1.0 ns
Pulse Width ≥200 ns
Z_in = 50 Ohms
Fall Time ≤ 1.0 ns
5.0 k
0.1 μF
5.0 k
130
V_out
V_in
51
TO SAMPLING SCOPE
Input Z ≥100 k
Rise Time ≤ 1.0 ns

NOTES: Collector Current = 10 mA, Turn-On and Turn-Off Time Base Currents = 0.5 mA.

FIGURE 3 – DC CURRENT GAIN

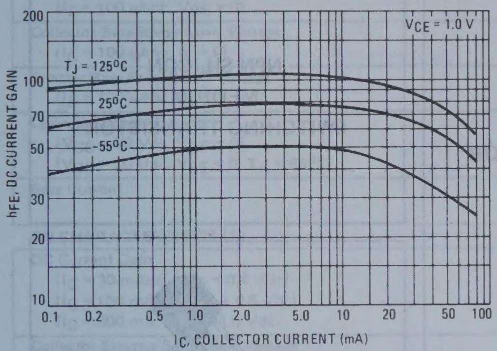


FIGURE 4 – "ON" VOLTAGES

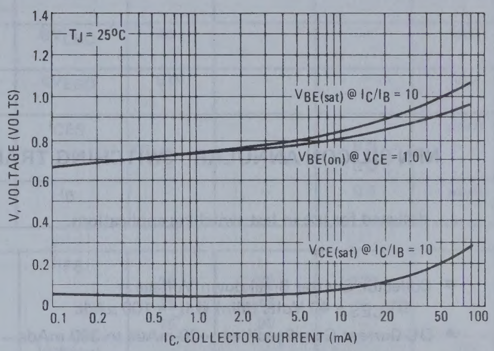


FIGURE 5 – COLLECTOR SATURATION REGION

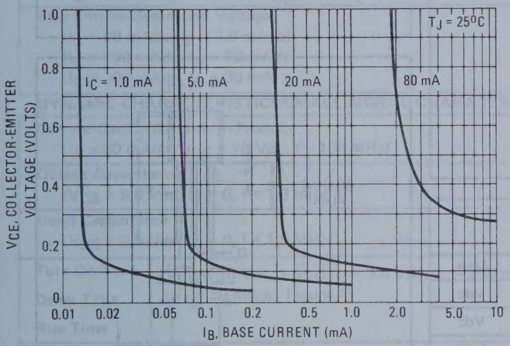


FIGURE 6 – TEMPERATURE COEFFICIENTS

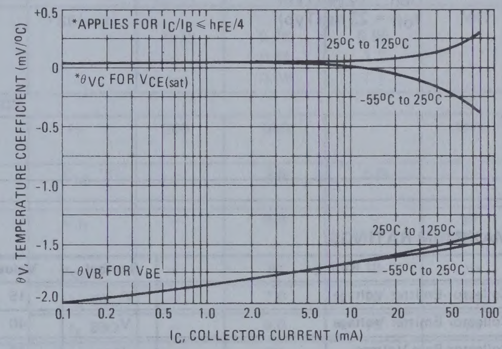


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

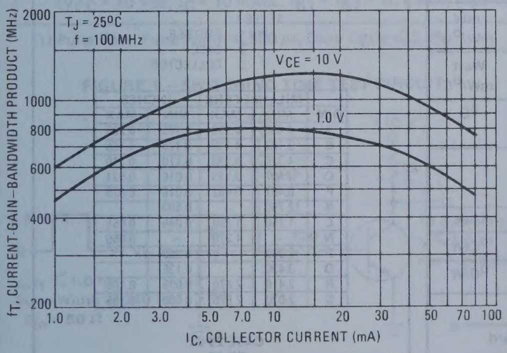
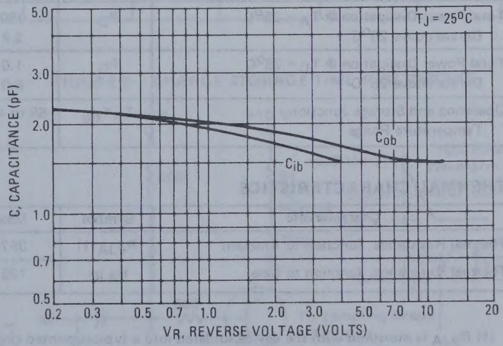


FIGURE 8 – CAPACITANCE



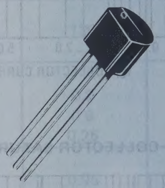
MPS3646 (SILICON)

NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in fast switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CES} = 40 Volts (Min) @ I_C = 100 μAdc
- DC Current Gain Specified — 30 mAdc to 300 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 300 mAdc
- Fast Switching Time @ I_C = 300 mAdc
  t_{on} = 16 ns (Typ)
  t_{off} = 23 ns (Typ)

NPN SILICON
MEDIUM
SWITCHING TRANSISTOR



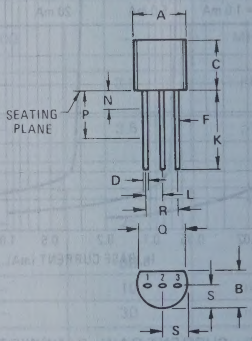
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous — 10 μs Pulse	I_C	300 500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

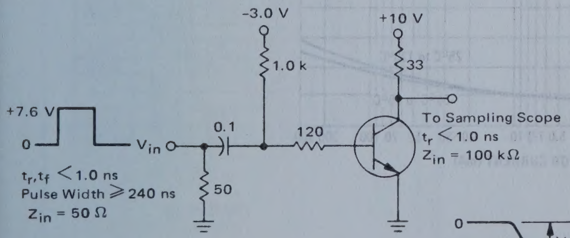
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$	15	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0) (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	 – –	 – –	 0.5 3.0	μAdc
Base Current	I_B	–	–	0.5	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 0.5 Vdc) (I_C = 300 mA, V_{CE} = 1.0 Vdc)	h_{FE}	 30 25 15	 65 48 20	 120 – –	–
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 30 mA, I_B = 3.0 mA, T_A = 65°C)	$V_{CE(sat)}$	 – – – –	 0.15 0.20 0.33 0.20	 0.2 0.28 0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 300 mAdc, I_B = 30 mA)	$V_{BE(sat)}$	 0.73 – –	 0.78 0.85 0.95	 0.95 1.2 1.7	Vdc
DYNAMIC CHARACTERISTICS/SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	600	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.5	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	8.8	–	pF
Turn-On Time (V_{CC} = 10 Vdc, $V_{BE(off)}$ = 3.0 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc, Figure 1)	t_{on}	–	16	18	ns
Delay Time	t_d	–	7.0	10	ns
Rise Time	t_r	–	9.0	15	ns
Turn-Off Time (V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = I_{B2} = 30 mAdc, Figure 1)	t_{off}	–	23	28	ns
Fall Time	t_f	–	7.0	15	ns
Storage Time (V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc, Figure 2)	t_s	–	–	18	ns

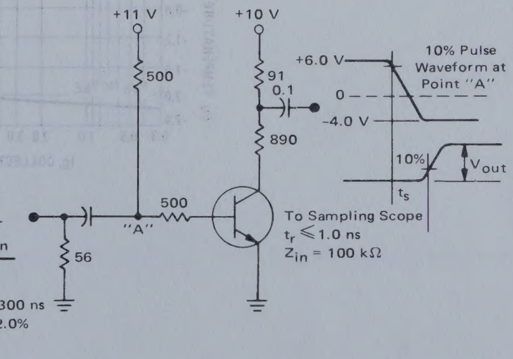
(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



-3.0 V
+10 V
1.0 k
33
+7.6 V
0
Vin
0.1
120
To Sampling Scope
tr < 1.0 ns
Zin = 100 kΩ
tr,tf < 1.0 ns
Pulse Width ⩾ 240 ns
Zin = 50 Ω
50

FIGURE 2 – CHARGE STORAGE TIME TEST CIRCUIT



+11 V
+10 V
500
91
0.1
890
+6.0 V
0
-4.0 V
10% Pulse Waveform at Point "A"
10%
Vout
ts
To Sampling Scope
tr ⩽ 1.0 ns
Zin = 100 kΩ
500
"A"
56
0
-10 V
Vin
tr < 1.0 ns
Pulse Width = 300 ns
Duty Cycle = 2.0%
Zin = 50 Ω

FIGURE 3 – DC CURRENT GAIN

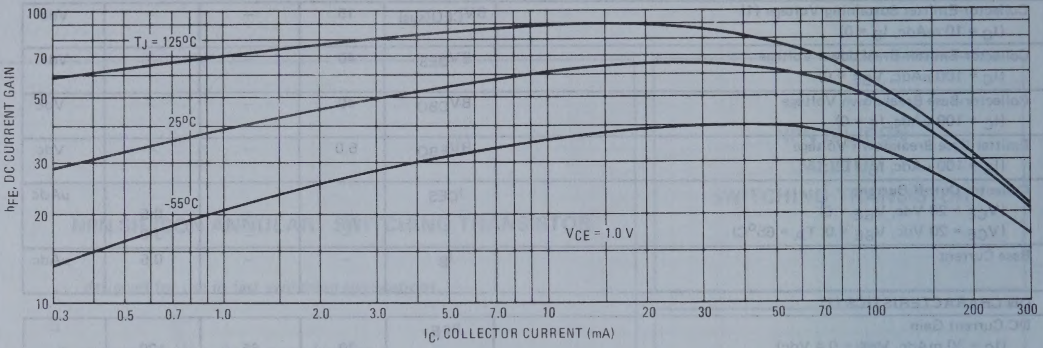


FIGURE 4 – "ON" VOLTAGES

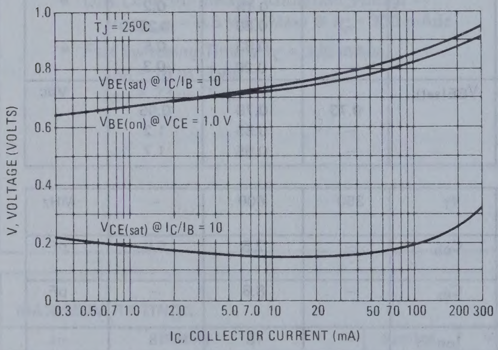


FIGURE 5 – COLLECTOR SATURATION REGION

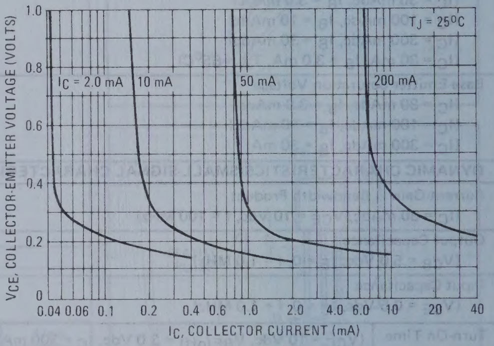


FIGURE 6 – TEMPERATURE COEFFICIENTS

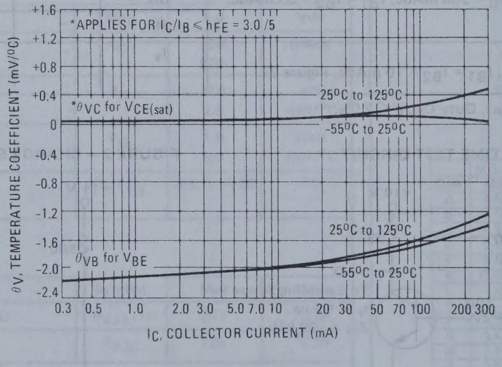


FIGURE 7 – COLLECTOR-BASE TIME CONSTANT

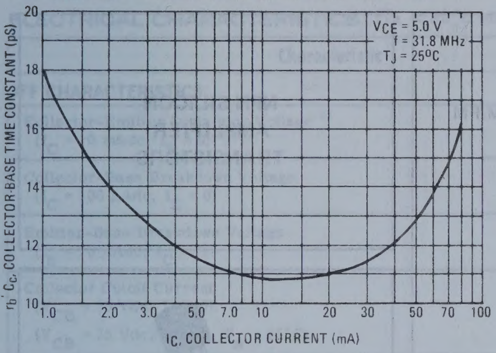


FIGURE 8 – CAPACITANCE

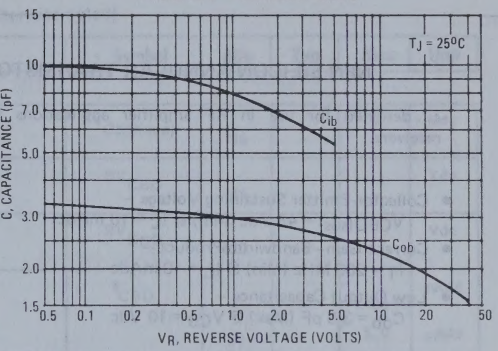
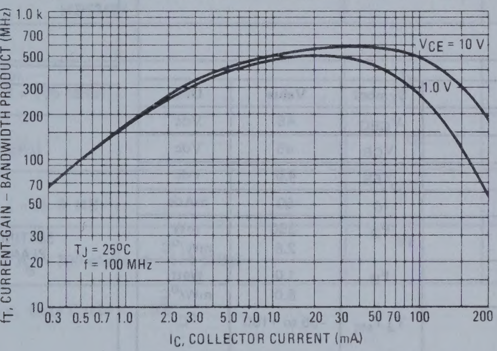


FIGURE 9 – CURRENT-GAIN – BANDWIDTH PRODUCT



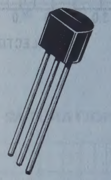
MPS3693 (SILICON)
MPS3694

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in RF amplifier applications and AM/FM receivers.

- Collector-Emitter Sustaining Voltage — $V_{CEO(sus)}$ = 45 Vdc (Min) @ I_C = 10 mAdc
- Current-Gain—Bandwidth Product — f_T = 200 MHz (Min) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 3.5 pF (Max) @ V_{CB} = 10 Vdc

NPN SILICON AMPLIFIER TRANSISTORS



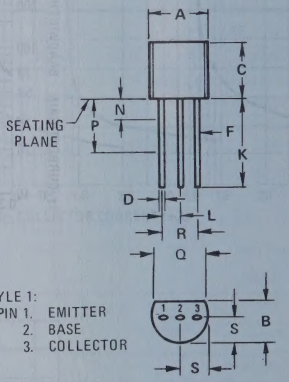
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[2] (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	45	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0) (V_{CB} = 35 Vdc, I_E = 0, T_A = 65° C)	I_{CBO}	- -	- -	50 5.0	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) MPS3693 MPS3694	h_{FE}	40 100	- -	160 400	-
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	200	-	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	-	3.5	pF
Collector-Base Time Constant (I_E = 10 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	r'_bC_c	-	-	55	ps
Noise Figure (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, R_S = 300 ohms, f = 1.0 MHz)	NF	-	4.0	-	dB

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

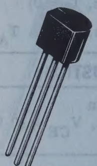
MPS3702 (SILICON)
MPS3703

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in low-current, large-signal amplifier applications.

- Device Similar Electrically to 2N3702, 2N3703

PNP SILICON AMPLIFIER TRANSISTOR



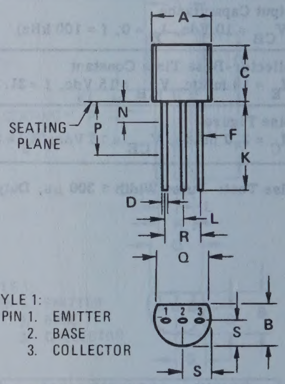
MAXIMUM RATINGS

Rating	Symbol	MPS3702	MPS3703	Unit
Collector-Emitter Voltage	V_{CEO}	25	30	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^\circ C$ Derate above $25^\circ C$	P_D	350 2.8		mW mW/°C
Total Power Dissipation @ $T_C = 25^\circ C$ Derate above $25^\circ C$	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the deviced soldered into a typical printed circuit board.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(2) ($I_C = 10$ mAdc, $I_B = 0$)	MPS3702 MPS3703	BV_{CEO}	25 30	- -	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	MPS3702 MPS3703	BV_{CBO}	40 50	- -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current ($V_{BE} = 3$ Vdc, $I_C = 0$)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain(2) ($I_C = 50$ mAdc, $V_{CE} = 5$ Vdc)	MPS3702 MPS3703	h_{FE}	60 30	300 150	-
Collector-Emitter Saturation Voltage(2) ($I_C = 50$ mAdc, $I_B = 5$ mAdc)		$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter On Voltage(2) ($I_C = 50$ mAdc, $V_{CE} = 5$ Vdc)		$V_{BE(on)}$	0.6	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 5$ Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, f = 1 MHz)		C_{ob}	-	12	pF

(2) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

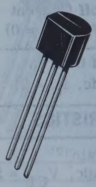
MPS3704 (SILICON)
MPS3705
MPS3706

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in low-current, large-signal amplifier applications.

- Devices Similar Electrically to 2N3704, 2N3705, 2N3706

NPN SILICON AMPLIFIER TRANSISTOR



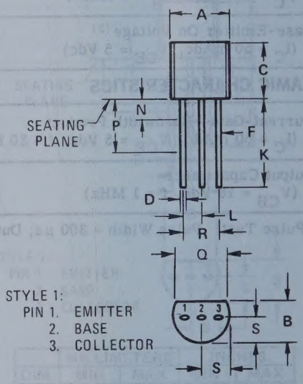
MAXIMUM RATINGS

Rating	Symbol	MPS3704 MPS3705	MPS3706	Unit
Collector-Emitter Voltage	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CB}	50	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8		mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0		Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the deviced soldered into a typical printed circuit board.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T$_A$ = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (2) (I_C = 10 mAdc, I_E = 0)	MPS3704	BV_{CEO}	30	-	Vdc
	MPS3705		30	-	
	MPS3706		20	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS3704	BV_{CBO}	50	-	Vdc
	MPS3705		50	-	
	MPS3706		40	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (2) (I_C = 50 mAdc, V_{CE} = 2 Vdc)	MPS3704	h_{FE}	100	300	-
	MPS3705		50	150	
	MPS3706		30	600	
Collector-Emitter Saturation Voltage (2) (I_C = 100 mAdc, I_B = 5 mAdc)	MPS3704	$V_{CE(sat)}$	-	0.6	Vdc
	MPS3705		-	0.8	
	MPS3706		-	1.0	
Base-Emitter On Voltage (2) (I_C = 100 mAdc, V_{CE} = 2 Vdc)		$V_{BE(on)}$	0.5	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2 Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	12	pF

(2) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

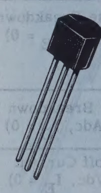
MPS3707 (SILICON)
MPS3709
MPS3710
MPS3711

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in low-current amplifier applications.

- Devices Similar Electrically to 2N3707, 2N3709, 2N3710, 2N3711

NPN SILICON AMPLIFIER TRANSISTORS



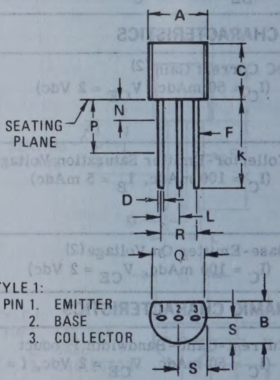
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage ($I_C = 1$ mAdc, $I_B = 0$)		BV_{CEO}	30	-	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current ($V_{EB} = 6$ Vdc, $I_C = 0$)		I_{EBO}	-	100	nAdc
DC Current Gain ($I_C = 100$ µAdc, $V_{CE} = 5$ Vdc) ($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc)	MPS3707 MPS3709 MPS3710 MPS3711	h_{FE}	100 45 90 180	400 165 330 660	-
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 0.5$ mAdc)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Voltage ($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc)		V_{BE}	0.5	1.0	Vdc
Small Signal Current Gain ($I_C = 100$ µAdc, $V_{CE} = 5$ Vdc, f = 1 kHz) ($I_C = 1$ mAdc, $V_{CE} = 5$ Vdc, f = 1 kHz)	MPS3707 MPS3709 MPS3710 MPS3711	h_{FE}	100 45 90 180	550 250 450 800	-
Noise Figure ($V_{CE} = 5$ V, $I_C = 100$ µA, $R_G = 5$ kΩ, Noise Bandwidth = 15.7 kHz) Note 1	MPS3707	NF	-	5.0	dB

Note 1 Average Noise Figure is measured in an amplifier with low frequency response down 3 dB at 10 Hz.

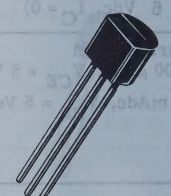
MPS3826 (SILICON)
MPS3827

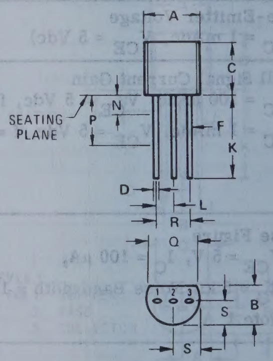
NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in general-purpose amplifier applications.

- Collector Emitter Breakdown Voltage – BV_{CEO} = 45 Vdc (Min) @ I_C = 10 mAdc
- High Current-Gain–Bandwidth Product – f_T = 500 MHz (Typ) @ I_C = 10 mAdc
- Low Output Capacitance – C_{ob} = 2.2 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON AMPLIFIER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 µAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 30 Vdc, I_E = 0)		–	–	100	nAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 85°C)		–	–	5.0	µAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) MPS3826	h_{FE}	40	–	160	–
MPS3827		100	175	400	–
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	500	800	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.2	3.5	pF
Collector-Base Time Constant (I_E = 10 mAdc, V_{CB} = 10 Vdc, f = 31.9 MHz)	$r_b'C_c$	–	–	100	ps

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle ⩽2.0%.

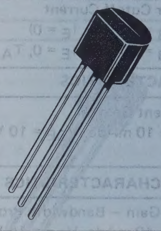
MPS4354 (SILICON)
MPS4355
MPS4356

PNP SILICON ANNULAR TRANSISTORS

. . . designed for low-level, low-noise amplifier and high-current switching applications.

- High Breakdown Voltages –
  BV_{CEO} = 60 and 80 Vdc (Min) @ I_C = 10 mAdc
  BV_{CBO} = 60 and 80 Vdc (Min) @ I_C = 10 μAdc
- Excellent Current Gain Linearity Specified –
  100 μAdc to 500 mAdc
- Low Noise Figure –
  NF = 2.0 dB (Typ) @ I_C = 100 μAdc, f = 100 Hz
- Low Saturation Voltages – MPS4355
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 1.0 Adc
  $V_{BE(sat)}$ = 1.2 Vdc (Max) @ I_C = 1.0 Adc

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS

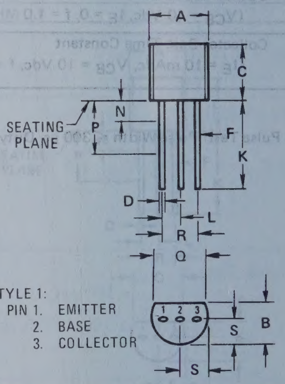


MAXIMUM RATINGS

Rating	Symbol	MPS4354 MPS4355	MPS4356	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1)		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	MPS4354,MPS4355		60	–	–	
	MPS4356		80	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 10 μAdc, I_E = 0)	MPS4354,MPS4355		60	–	–	
	MPS4356		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 50 Vdc, I_E = 0)			–	–	50	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = +75°C)			–	–	5.0	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356		25	–	–	
	MPS4355		60	–	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356		40	–	–	
	MPS4355		75	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS4354		50	–	500	
	MPS4355		100	–	400	
	MPS4356		50	–	250	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356		40	–	–	
	MPS4355		75	–	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPS4354,MPS4356		30	–	–	
	MPS4355		75	–	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.15	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	–	0.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)	MPS4355		–	–	1.0	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.9	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	–	1.1	
(I_C = 1.0 Adc, I_B = 100 mAdc)	MPS4355		–	–	1.2	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 500 mAdc, V_{CE} = 0.5 Vdc)			–	–	1.1	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MPS4355		–	–	1.2	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	–	500	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	–	30	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	–	–	110	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	–	550	–	Ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	–	100	–	X 10^{-6}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	–	200	–	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	100	–	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)		NF	–	–	3.0	dB
SWITCHING CHARACTERISTICS						
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)		t_{on}	–	–	100	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)		t_{off}	–	–	400	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

TYPICAL DYNAMIC CHARACTERISTICS

NOISE FIGURE

FIGURE 1 – SOURCE RESISTANCE EFFECTS

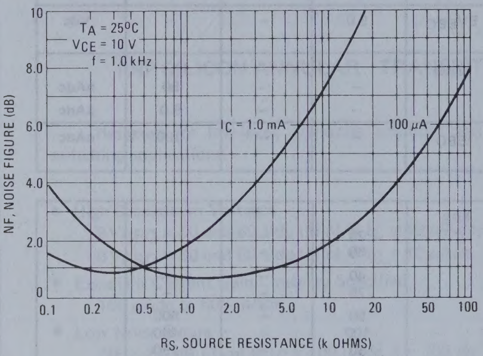


FIGURE 2 – FREQUENCY EFFECTS

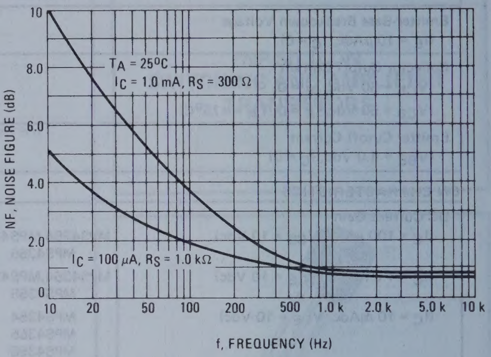


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

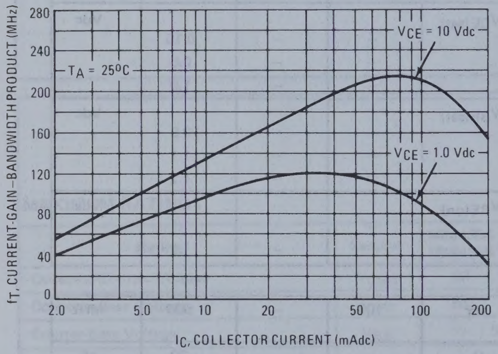


FIGURE 4 – CAPACITANCES

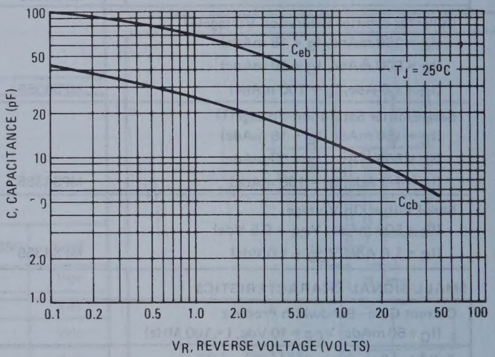


FIGURE 5 – SWITCHING TIMES

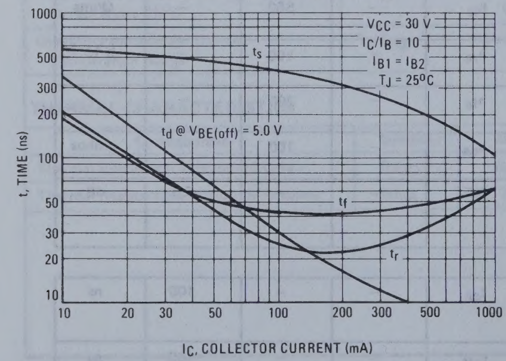
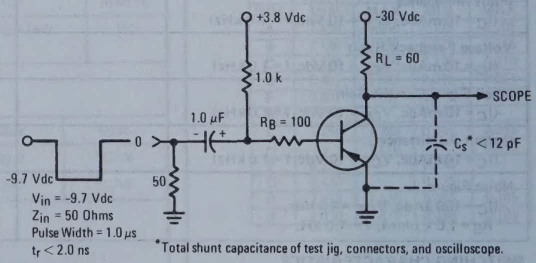


FIGURE 6 – SWITCHING TIME TEST CIRCUIT


+3.8 Vdc
-30 Vdc
R_L = 60
1.0 k
SCOPE
1.0 μF
R_B = 100
0
-9.7 Vdc
50
C_s* < 12 pF

V_{in} = -9.7 Vdc
Z_{in} = 50 Ohms
Pulse Width = 1.0 μs
$t_r < 2.0$ ns

*Total shunt capacitance of test jig, connectors, and oscilloscope.

TYPICAL DC CHARACTERISTICS

DC CURRENT GAIN

FIGURE 7 – MPS4354, MPS4356

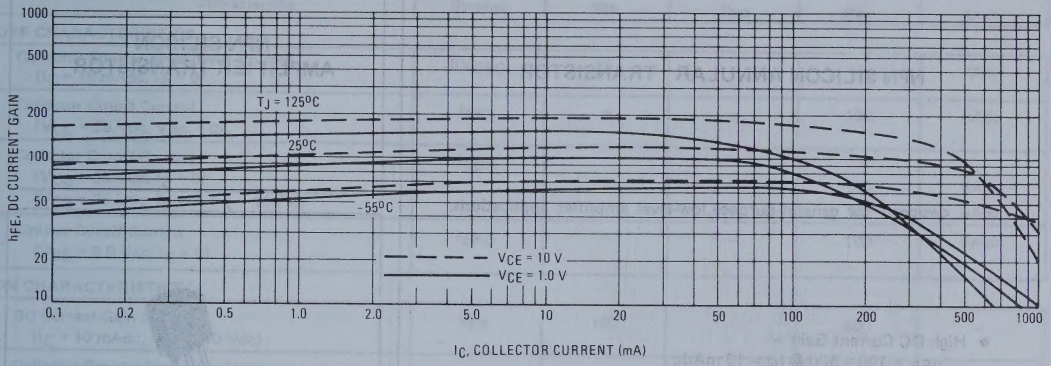


FIGURE 8 – MPS4355

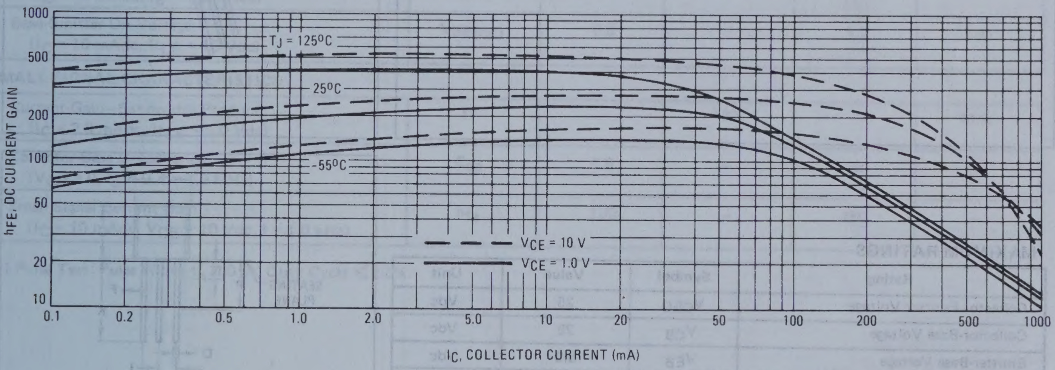


FIGURE 9 – "ON" VOLTAGES

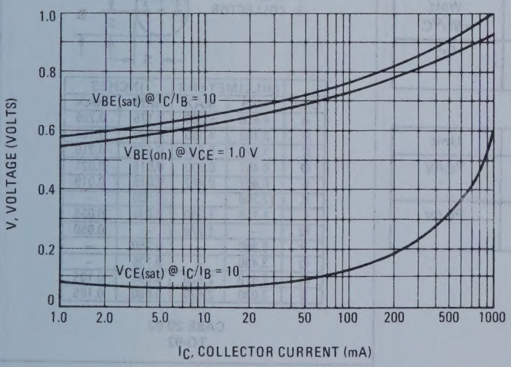
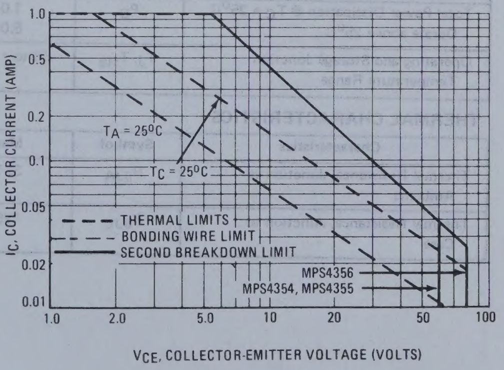


FIGURE 10 – DC SAFE OPERATING AREA



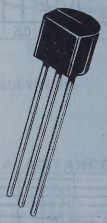
MPS5172 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, low-level amplifier applications.

- High DC Current Gain —
  h_{FE} = 100 - 500 @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc

NPN SILICON AMPLIFIER TRANSISTOR

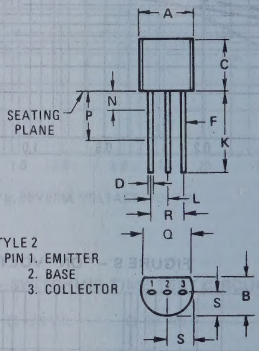


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W



STYLE 2
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	25	–	–	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0)	I_{CES}	–	–	100	nAdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 25 Vdc, I_E = 0)		–	–	100	nAdc
(V_{CB} = 25 Vdc, I_E = 0, T_A = 100°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	–	500	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.75	–	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	0.5	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	f_T	–	120	–	MHz
Collector-Base Capacitance (V_{CB} = 0, I_E = 0, f = 1.0 MHz)	C_{cb}	1.6	–	10	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	–	750	–

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

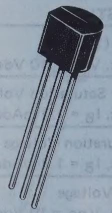
MPS6507 (SILICON)

NPN SILICON ANNULAR VHF/UHF AMPLIFIER TRANSISTOR

. . . designed for use in VHF/UHF amplifier applications.

- High Collector Emitter Breakdown Voltage —
  BV_{CEO} = 20 Vdc (Min) @ I_C = 1.0 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 800 MHz (Typ) @ I_C = 10 mAdc
- Low Output Capacitance —
  C_{ob} = 1.25 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON VHF/UHF AMPLIFIER TRANSISTOR



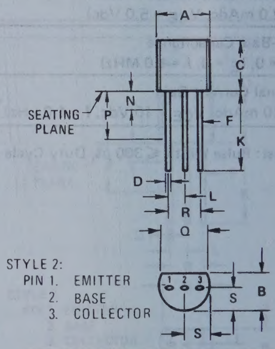
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 2:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 60°C)	I_{CBO}	– –	– –	50 1.0	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	75	–	–
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	800	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	1.25	2.5	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 44 MHz)	h_{fe}	20	–	–	–

(1) Pulse Test: Pulse Width $\leqslant$300 μs, Duty Cycle $\leqslant$2.0%.

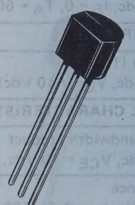
MPS6511 (SILICON)

NPN SILICON ANNULAR VHF/UHF AMPLIFIER TRANSISTOR

. . . designed for use in VHF/UHF amplifier applications.

- High Collector Emitter Breakdown Voltage — BV_{CEO} = 20 Vdc (Min) @ I_C = 0.5 mAdc
- Low Output Capacitance — C_{ob} = 1.25 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON
VHF/UHF AMPLIFIER
TRANSISTOR



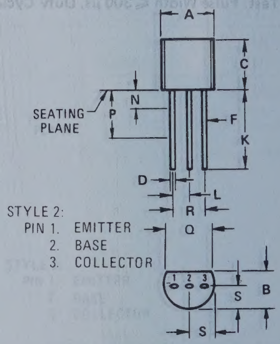
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 2:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 0.5 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 100 μAdc, V_{EB} = 0)	BV_{CES}	30	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	75	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	1.25	2.5	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (I_C = 10 mAdc, V_{CB} = 12 Vdc, f = 45 MHz)	G_{pe}	30	–	–	dB

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

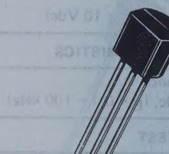
MPS6512 thru MPS6515 NPN (SILICON)
MPS6516 thru MPS6519 PNP (SILICON)

SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry.

- Narrow DC Current Gain Ranges – 2:1
- Complementary Types for Each Gain Range
- Low Noise Figure – 2.0 dB Typ
- Low Output Capacitance – 3.5 pF Max – NPN
  4.0 pF Max – PNP

SILICON COMPLEMENTARY AMPLIFIER TRANSISTORS

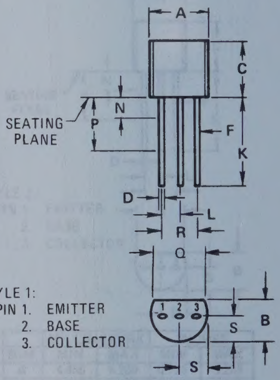


MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6512, MPS6513		30	–	
MPS6514, MPS6515		25	–	
MPS6516 thru MPS6518		–	40	
MPS6519		–	25	
Collector-Base Voltage	V_{CB}			Vdc
MPS6512 thru MPS6515		40	–	
MPS6516 thru MPS6518		–	40	
MPS6519		–	25	
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current – Continuous	I_C	100	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	1.0 8.0	Watt mW/°C
Operating Junction Temperature Range	T_J	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MPS6512 thru MPS6515 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	MPS6512, MPS6513	BV_{CEO}	30	-	-	Vdc
	MPS6514, MPS6515		25	-	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	-	0.05	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)			-	-	1.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6512	h_{FE}	50	-	100	-
	MPS6513		90	-	180	
	MPS6514		150	-	300	
	MPS6515		250	-	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)(1)	MPS6512		30	-	-	
	MPS6513		60	-	-	
	MPS6514		90	-	-	
	MPS6515		150	-	-	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	-	-	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513	f_T	-	250	-	MHz
	MPS6514, MPS6515		-	390	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513		-	330	-	
	MPS6514, MPS6515		-	480	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}		-	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	-	2.0	-	dB

* Pulse Test: Pulse Width ≦ 30 μs, Duty Cycle ≦ 2.0%.

MPS6516 thru MPS6519 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	MPS6516 thru MPS6518	BV_{CEO}	40	-	-	Vdc
	MPS6519		25	-	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	MPS6516 thru MPS6518	I_{CBO}	-	-	0.05	μAdc
(V_{CB} = 20 Vdc, I_E = 0)	MPS6519		-	-	0.05	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	MPS6516 thru MPS6518		-	-	1.0	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	MPS6519		-	-	1.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6516	h_{FE}	50	-	100	-
	MPS6517		90	-	180	
	MPS6518		150	-	300	
	MPS6519		250	-	500	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)(1)	MPS6516		30	-	-	
	MPS6517		60	-	-	
	MPS6518		90	-	-	
	MPS6519		150	-	-	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	-	-	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6516, MPS6517	f_T	-	200	-	MHz
	MPS6518, MPS6519		-	340	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6516, MPS6517		-	270	-	
	MPS6518, MPS6519		-	420	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	-	2.0	-	dB

(1) Pulse Test: Pulse Width ≦ 30 μs, Duty Cycle ≦ 2.0%.

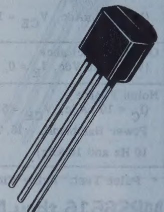
MPS6520, MPS6521 NPN (SILICON)
MPS6522, MPS6523 PNP

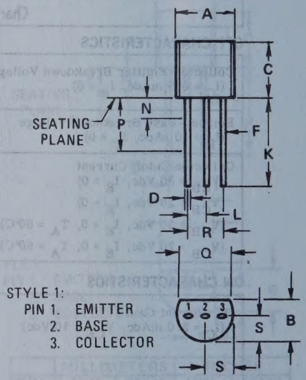
SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry.

- High DC Current Gain —
  h_{FE} = 150 (Min) @ I_C = 100 µAdc – MPS6521, MPS6523
- Low Noise Figure —
  NF = 1.8 dB (Typ) @ I_C = 10 µAdc
- Low Output Capacitance —
  C_{ob} = 3.5 pF (Max) @ V_{CB} = 10 Vdc

SILICON COMPLEMENTARY AMPLIFIER TRANSISTORS





	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATING

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6520,MPS6521		25		
MPS6522,MPS6523			25	
Collector-Base Voltage	V_{CB}			Vdc
MPS6520,MPS6521		40		
MPS6522,MPS6523			25	
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	350 2.81	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	1.0 8.0	Watt mW/°C
Operating Junction Temperature Range	T_J	150	150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	357	°C/ W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/ W

MPS6520, MPS6521, MPS6522, MPS6523 (continued)

MPS6520, MPS6521 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	BV_{CEO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	I_{CBO}	 — —	 — —	 0.05 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) MPS6520 MPS6521 (I_C = 2.0 mAdc, V_{CE} = 10 Vdc) MPS6520 MPS6521	h_{FE}	 100 150 200 300	 — — — —	 — — 400 600	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	 — —	 390 480	 — —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	—	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)	NF	—	1.8	3.0	dB

MPS6522, MPS6523 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	BV_{CEO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	I_{CBO}	 — —	 — —	 0.05 1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) MPS6522 MPS6523 (I_C = 2.0 mAdc, V_{CE} = 10 Vdc) MPS6522 MPS6523	h_{FE}	 100 150 200 300	 — — — —	 — — 400 600	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	—	—	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	 — —	 340 420	 — —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	—	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)	NF	—	1.8	3.0	dB

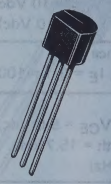
MPS6530
MPS6531
MPS6532
NPN (SILICON)
MPS6533
MPS6534
MPS6535
PNP (SILICON)

NPN/PNP SILICON ANNULAR TRANSISTORS

. . . designed for use in complementary amplifier applications.

- Collector-Emitter Breakdown @ I_C = 10 mAdc
  BV_{CEO} = 40 Vdc (Min) MPS6530,6531,6533,6534
  30 Vdc (Min) MPS6532,6535
- DC Current Gain Specified – 10 mAdc to 500 mAdc
- Current-Gain–Bandwidth Product @ I_C = 50 mAdc
  f_T = 390 MHz (Typ) NPN
  260 MHz (Typ) PNP

NPN/PNP SILICON
COMPLEMENTARY
AMPLIFIER
TRANSISTORS



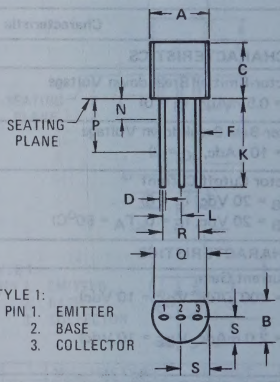
MAXIMUM RATINGS

Rating	Symbol	NPN	PNP	Unit
Collector-Base Voltage	V_{CB}			Vdc
MPS6530, MPS6531, MPS6532		60		
MPS6532		50		
MPS6533, MPS6534			40	
MPS6535			30	
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6530, MPS6531		40		
MPS6532		30		
MPS6533, MPS6534			40	
MPS6535			30	
Emitter-Base Voltage	V_{EB}	5.0	4.0	Vdc
Collector Current – Continuous	I_C	600		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MPS6530 thru MPS6532 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6530, MPS6531 MPS6532	BV_{CBO}	60 50	- -	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6530, MPS6531 MPS6532	BV_{CEO}	40 30	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	 MPS6530, MPS6531 MPS6532 MPS6530, MPS6531 MPS6532	I_{CBO}	 - - - -	 - - - -	 0.05 0.1 2.0 5.0	μAdc
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1 Vdc)	 MPS6530 MPS6531	h_{FE}	 30 60	 75 120	 - -	-
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	MPS6530 MPS6531 MPS6532		40 90 30	85 150 -	120 270 -	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPS6530 MPS6531		25 50	60 80	- -	
Collector-Emitter Saturation Voltage (1) (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6532 MPS6531	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6531 MPS6532	$V_{BE(sat)}$	- -	0.82 0.85	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	3.5	5.0	pF
Current-Gain–Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc)		f_T	-	390	-	MHz

MPS6533 thru MPS6535 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6533, MPS6534 MPS6535	BV_{CBO}	40 30	- -	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6533, MPS6534 MPS6535	BV_{CEO}	40 30	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	 MPS6533, MPS6534 MPS6535 MPS6533, MPS6534 MPS6535	I_{CBO}	 - - - -	 - - - -	 0.05 0.1 2.0 5.0	μAdc
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1 Vdc)	 MPS6533 MPS6534	h_{FE}	 30 60	 70 110	 - -	-
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	MPS6533 MPS6534 MPS6535		40 90 30	85 140 -	120 270 -	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPS6533 MPS6534		25 50	55 70	- -	
Collector-Emitter Saturation Voltage (1) (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6535 MPS6534	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6534 MPS6535	$V_{BE(sat)}$	- -	0.84 0.87	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.8	6.0	pF
Current-Gain–Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc)		f_T	-	260	-	MHz

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

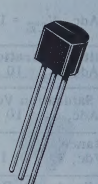
MPS6539 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for RF applications in FM receivers.

- Low Feedback Capacitance — $C_{cb} = 0.7$ pF (Max)
- High Current-Gain—Bandwidth Product $f_T = 500$ MHz
- Low Noise Figure — NF = 4.5 dB (Max) @ 100 MHz

NPN SILICON
RF AMPLIFIER
TRANSISTOR



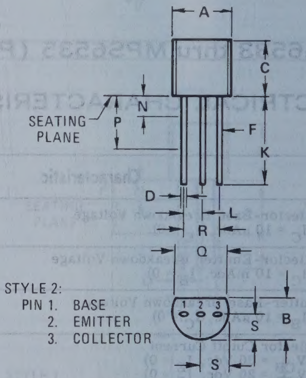
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	-
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 mHz)	f_T	500	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.7	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b{'}C_c$	-	9.0	ps
Noise Figure (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz)	NF	-	4.5	dB

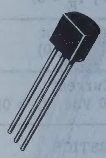
MPS6540 (SILICON)

NPN SILICON ANNULAR AMPLIFIER/ MIXER TRANSISTOR

. . . designed for use in high frequency amplifier and mixer applications.

- High Collector Emitter Breakdown Voltage — $BV_{CEO} = 30$ Vdc (Min) @ $I_C = 1.0$ mAdc
- High Current-Gain—Bandwidth Product — $f_T = 800$ MHz (Typ) @ $I_C = 2.0$ mAdc
- Low Feedback Capacitance — $C_{cb} = 0.5$ pF (Typ) @ $V_{CB} = 10$ Vdc

NPN SILICON AMPLIFIER/MIXER TRANSISTOR



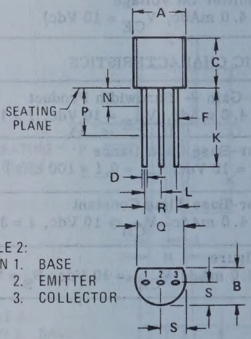
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25^\circ C$ Derate above 25°C	P_D	350 5.0	mW mW/°C
Total Power Dissipation @ $T_C = 25^\circ C$ Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	100	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.3	0.5	Vdc
Base-Emitter On Voltage (1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.1	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	800	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.5	0.65	pF
Real Part of Output Impedance (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 10.7 MHz)	R_{oep}	80	–	–	k Ohms

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

MPS6541 (SILICON)

NPN SILICON ANNULAR VHF/UHF AMPLIFIER TRANSISTOR

. . . designed for use in VHF amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 20 Vdc (Min) @ I_C = 0.5 mAdc
- Low Output Capacitance — C_{ob} = 1.25 pF (Typ) @ 15 Vdc

MAXIMUM RATINGS

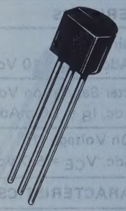
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

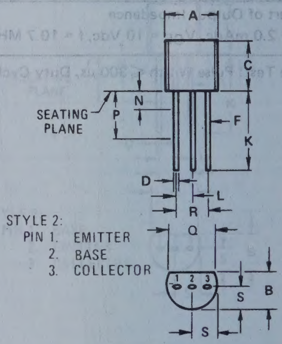
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON
VHF/UHF AMPLIFIER
TRANSISTOR





STYLE 2:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

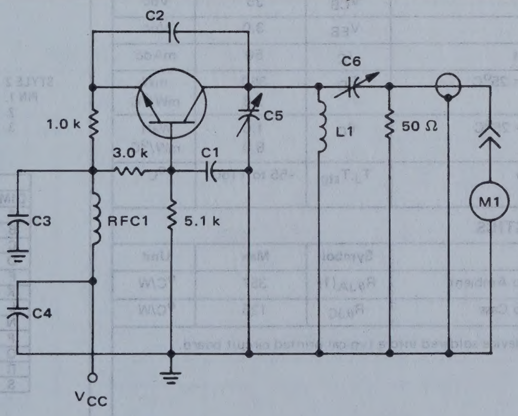
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 0.5$ mAdc, $I_B = 0$)	BV_{CEO}	20	–	–	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\ \mu$Adc, $V_{BE} = 0$)	BV_{CES}	30	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$) ($V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 60^{\circ}C$)	I_{CBO}	– –	– –	0.05 1.0	µAdc µAdc
Emitter Cutoff Current ($V_{BE} = 4.0$ Vdc, $I_C = 0$)	I_{EBO}	–	–	1.0	µAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	75	–	–
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	h_{fe}	6.0	–	15	–
Output Capacitance ($V_{CB} = 15$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	–	1.25	1.7	pF
FUNCTIONAL TEST					
Power Output (Figure 1) ($V_{CC} = 12$ Vdc, $I_C = 4.0$ mAdc, f = 257 MHz)	P_{out}	10	–	–	mW

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.

FIGURE 1 – OSCILLATOR POWER OUTPUT TEST CIRCUIT



C1	100 pF Button-Type Capacitor, ERIE or Equivalent	M1	BOONTON 91CA Voltmeter or Equivalent
C2	1.0 pF ARCO ELEMENCO DUR MICA or Equivalent	L1	0.03 µH, Q = 190, 2T, #20 Bus Wire, I.D. 9/16'', Length 1/8''
C3,C4	470 pF DISC Capacitor, SPRAGUE or Equivalent	RFC1	0.47 µH, Q = 80 JEFFERS or Equivalent
C5,C6	1.1 pF JOHANSON PART NO. 2951 or Equivalent		

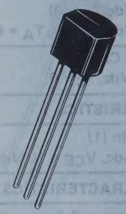
MPS6543 (SILICON)

NPN SILICON ANNULAR RF AMPLIFIER TRANSISTOR

. . . designed for use in RF amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 25 Vdc (Min) @ I_C = 1.0 mAdc
- High Current-Gain—Bandwidth Product — f_T = 1100 MHz (Typ) @ I_C = 4.0 mAdc
- Low Output Capacitance — C_{ob} = 0.8 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON RF AMPLIFIER TRANSISTOR



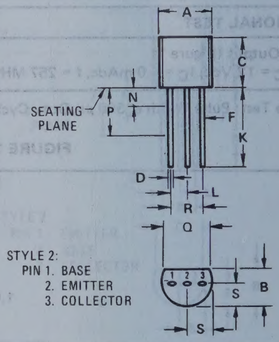
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MPS6543 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	35	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	–	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	–	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	60	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	200	350	mVdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	750	950	mVdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	750	1100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	–	0.8	1.0	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CE} = 12 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	–	9.5	ps

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

MPS6544, MPS6545 (SILICON)

NPN SILICON ANNULAR VHF MIXER TRANSISTORS

. . . designed for use in VHF mixer applications.

- Collector-Emitter Breakdown Voltage
  BV_{CEO} = 45 Vdc (Min) @ I_C = 1.0 mAdc
- Low Feedback Capacitance –
  C_{re} = 0.5 pF (Typ) @ V_{CB} = 10 Vdc – MPS6545

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

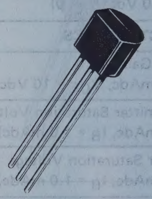
THERMAL CHARACTERISTICS

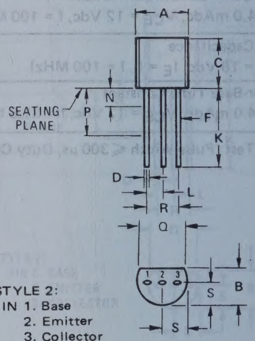
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

*Indicates JEDEC Registered Data

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON VHF MIXER TRANSISTORS





STYLE 2:
PIN 1. Base
2. Emitter
3. Collector

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

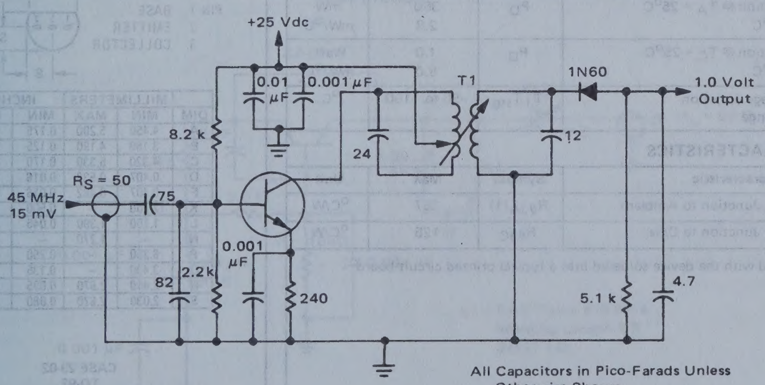
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	45	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 35$ Vdc, $I_E = 0$)	I_{CBO}	–	–	500	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	100	–	–
Collector-Emitter Saturation Voltage ($I_C = 30$ mAdc, $I_B = 3.0$ mAdc)	$V_{CE(sat)}$	–	0.2	0.5	Vdc
Base-Emitter On Voltage (1) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	–	0.7	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Output Admittance ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 45 MHz)	y_{oe}	–	–	0.10	mmhos
Common-Emitter Reverse Transfer Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz) MPS6544 MPS6545	C_{re}	 – –	 0.55 0.5	 0.65 0.58	pF
Output Voltage (V_{in} (RMS) = 15 mVdc, f = 45 MHz)	V_{out}	1.0	–	–	Vdc

(1) Pulse Test: Pulse Width ≤300 µs, Duty Cycle ≤2.0%.

FIGURE 1 – OUTPUT VOLTAGE TEST CIRCUIT



All Capacitors in Pico-Farads Unless
Otherwise Shown

T1 – Primary: 7 Turns #26 Wire,
1/4" I.D., Tapped 5 Turns
From Collector.
Secondary: 10 Turns #26 Wire, 1/4" I.D.
Core: ARNOLD Iron Powder, Part No. A1-10

For MPS6545 Shield is Connected to Ground.

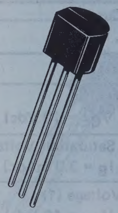
MPS6546 (SILICON)

NPN SILICON ANNULAR VHF MIXER TRANSISTOR

. . . designed for use in VHF mixer applications.

- Collector Emitter Breakdown Voltage — BV_{CEO} = 25 Vdc (Min) @ I_C = 1.0 mAdc
- High Current Gain—Bandwidth Product f_T = 1000 MHz (Typ) @ I_C = 10 mAdc
- Low Feedback Capacitance — C_{re} = 0.4 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON
VHF MIXER TRANSISTOR



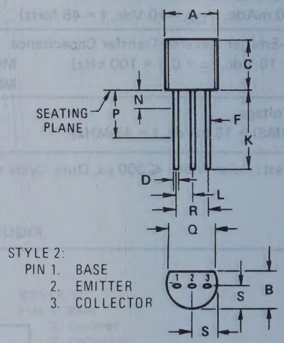
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

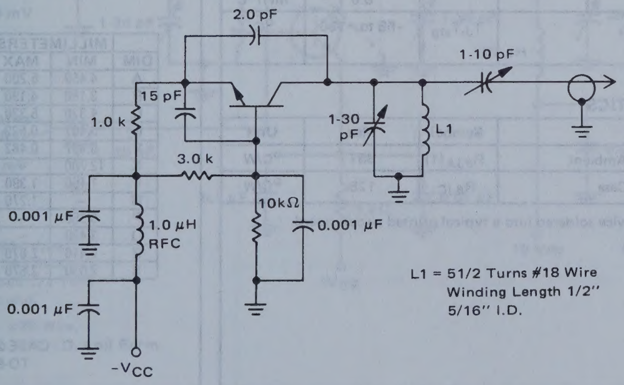
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	25	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	35	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 25$ Vdc, $I_E = 0$)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	–	–	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 2.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	20	60	–	–
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	–	0.15	0.35	Vdc
Base-Emitter On Voltage (1) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	–	0.7	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	600	1000	–	MHz
Common-Emitter Reverse Transfer Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{re}	–	0.4	0.45	pF
FUNCTIONAL TEST					
Power Output (Figure 1) ($V_{CE} = 12.5$ Vdc, f = 118 MHz)	P_{out}	10	–	–	mW

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 — OSCILLATOR POWER OUTPUT TEST CIRCUIT



L1 = 51/2 Turns #18 Wire
Winding Length 1/2″
5/16″ I.D.

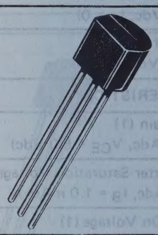
MPS6547 (SILICON)

NPN SILICON ANNULAR RF AMPLIFIER TRANSISTOR

. . . designed for use in RF amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 25 Vdc (Min) @ I_C = 1.0 mAdc
- High-Current-Gain—Bandwidth Product — f_T = 1000 MHz (Typ) @ I_C = 2.0 mAdc
- Low Feedback Capacitance — C_{re} = 0.3 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON RF AMPLIFIER TRANSISTOR



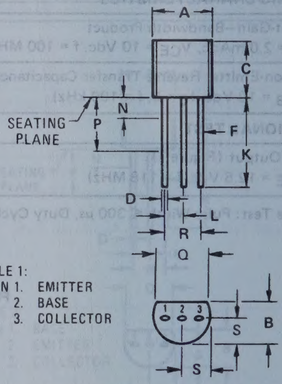
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

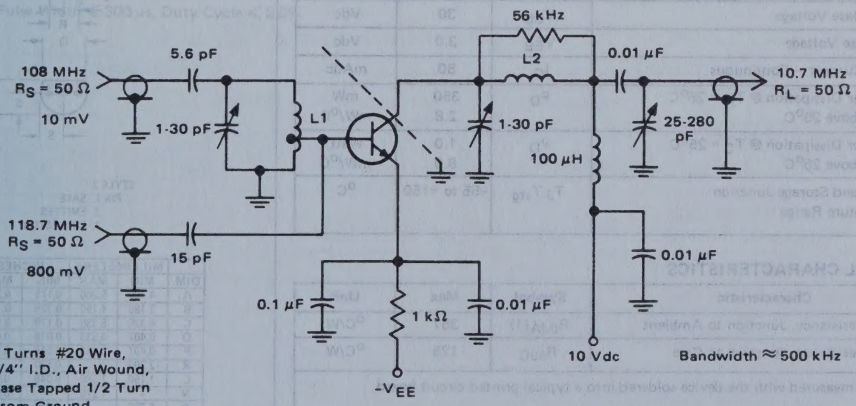
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	35	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	–	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	60	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.1	0.35	Vdc
Base-Emitter On Voltage (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	0.7	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1000	–	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{re}	–	0.3	0.35	pF
Conversion Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc (Test Circuit Figure 1) f = 100 MHz to 10.7 MHz)	G_{pe}	20	25	–	dB

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.


108 MHz
R_S = 50 Ω
10 mV
5.6 pF
1-30 pF
L1
118.7 MHz
R_S = 50 Ω
800 mV
15 pF
56 kHz
L2
0.01 μF
10.7 MHz
R_L = 50 Ω
1-30 pF
25-280 pF
100 μH
0.01 μF
0.1 μF
1 kΩ
0.01 μF
$-V_{EE}$
10 Vdc
Bandwidth ≈ 500 kHz

L1 = 3 Turns #20 Wire,
1/4″ I.D., Air Wound,
Base Tapped 1/2 Turn
From Ground.

L2 = 37 Turns #28 Wire,
Wound on 1/4″ I.D. Coil Form.

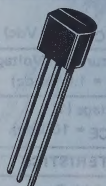
MPS6548 (SILICON)

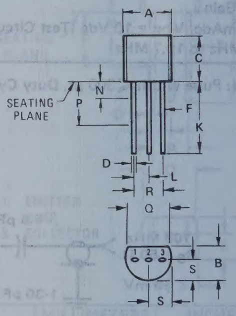
NPN SILICON ANNULAR VHF/UHF OSCILLATOR TRANSISTOR

. . . designed for use in VHF/UHF common-base oscillator applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 25 Vdc (Min) @ I_C = 1.0 mAdc
- High DC Current Gain — h_{FE} = 125 (Typ) @ I_C = 4.0 mAdc
- High Current-Gain—Bandwidth Product — f_T = 1500 MHz (Typ) @ I_C = 4.0 mAdc
- Low Collector-Base Capacitance — C_{cb} = 0.5 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON VHF/UHF OSCILLATOR TRANSISTOR





STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	125	–	–
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{BE(sat)}$	–	–	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	1500	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.5	0.7	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	–	9.0	ps

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

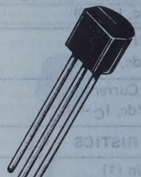
MPS6560 NPN (SILICON)
MPS6562 PNP

SILICON ANNULAR AUDIO TRANSISTORS

. . . designed for complementary symmetry audio output applications.

- Excellent Gain Linearity –
  From 10 mAdc to 100 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 500 mAdc

NPN/PNP SILICON AUDIO TRANSISTORS



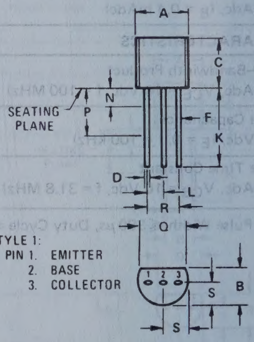
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector-Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	$T_J\ T_{stg}$	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/mW

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	–	25	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	–	25	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, I_B = 0)	I_{CEO}	–	100	nAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 35 50 50	 – – 200	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	30	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

TYPICAL CHARACTERISTICS

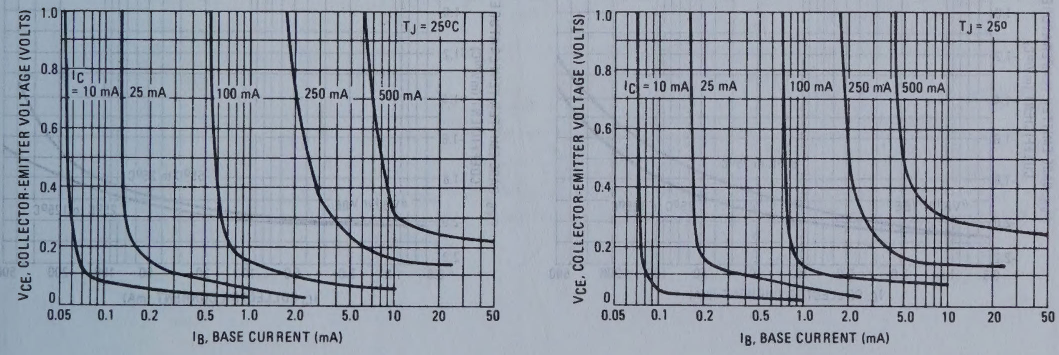

MPS6560 NPN **MPS6562 PNP**

FIGURE 1 – COLLECTOR SATURATION REGION

TYPICAL CHARACTERISTICS (continued)

MPS6560 NPN **MPS6562 PNP**

FIGURE 2 – DC CURRENT GAIN

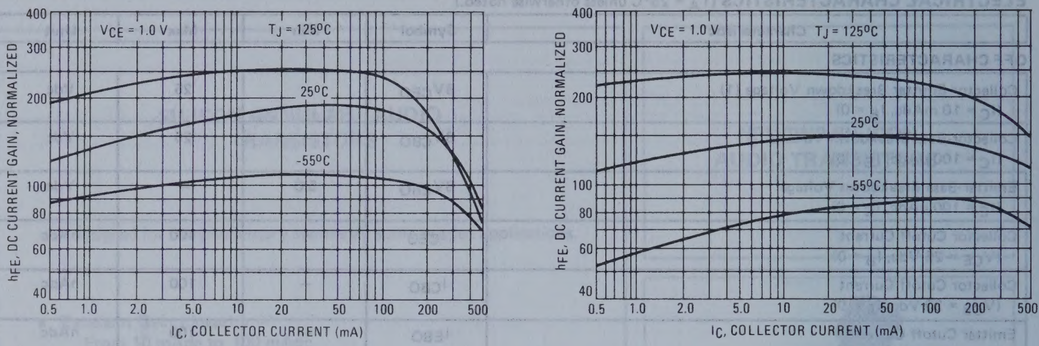


FIGURE 3 – "ON" VOLTAGE

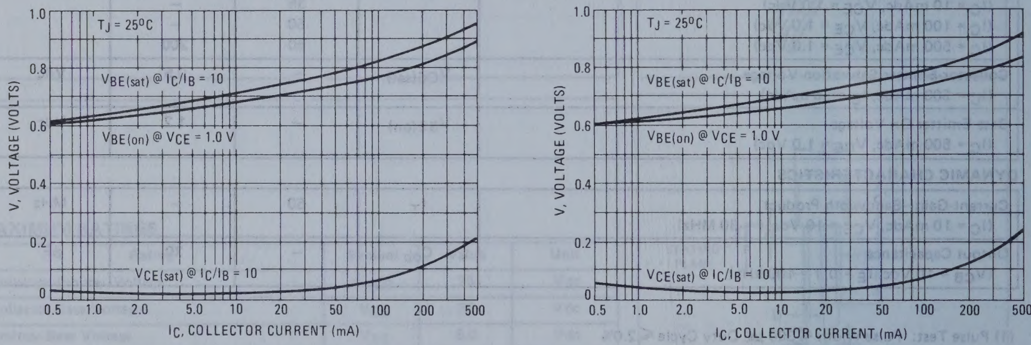
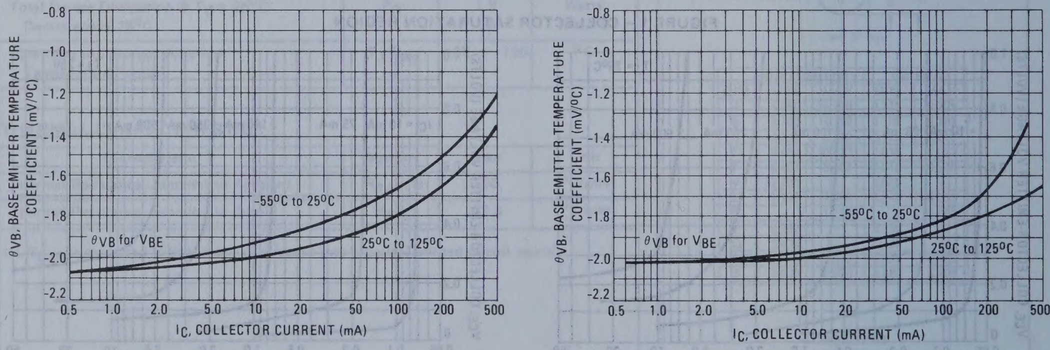


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT



TYPICAL CHARACTERISTICS

MPS6560 NPN **MPS6562 PNP**

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

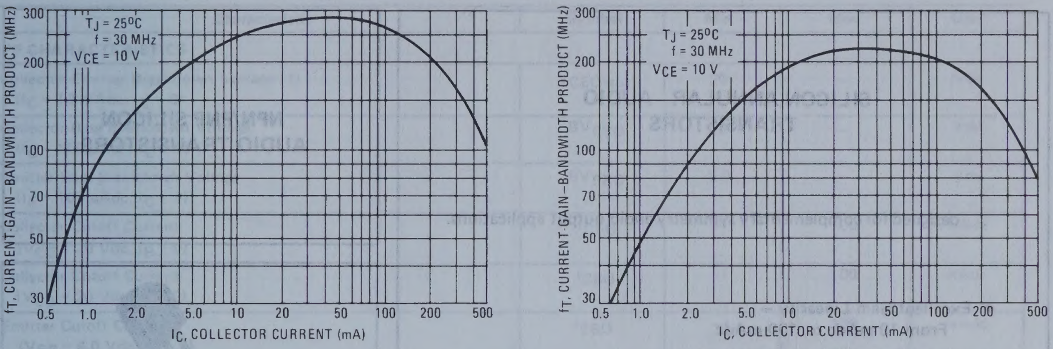
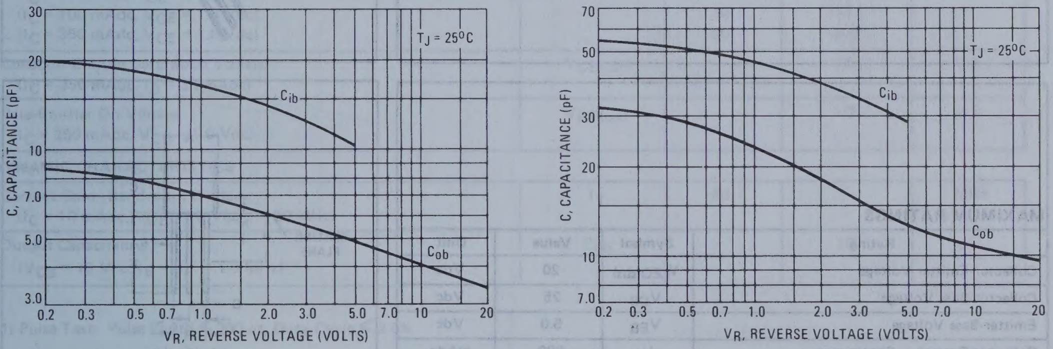


FIGURE 6 – CAPACITANCE



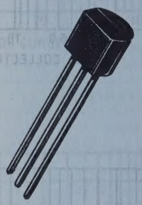
MPS6561 NPN (SILICON)
MPS6563 PNP

SILICON ANNULAR AUDIO TRANSISTORS

. . . designed for complementary symmetry audio output applications.

- Excellent Gain Linearity – From 10 mAdc to 100 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 350 mAdc

NPN/PNP SILICON AUDIO TRANSISTORS



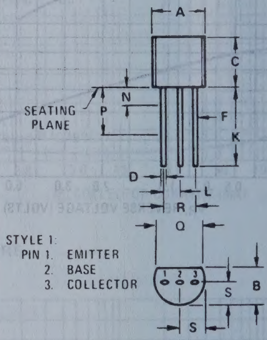
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	$V_{CEO(sus)}$	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector-Current – Continuous	I_C	600	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

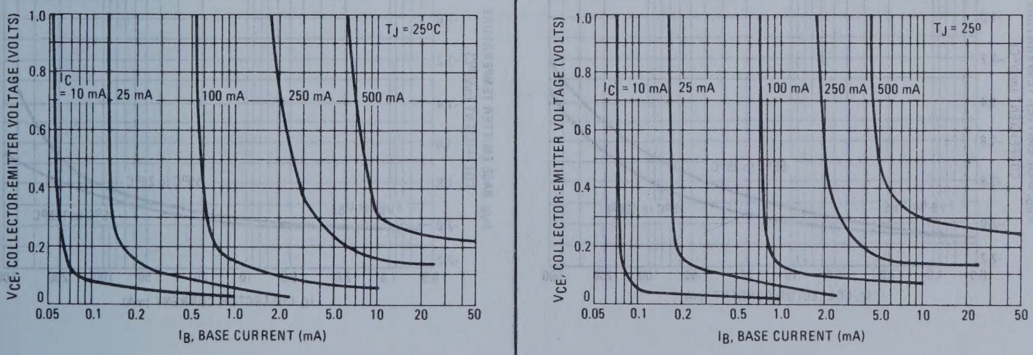
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	–	100	nAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 350 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 35 50 50	 – – 200	–
Collector-Emitter Saturation Voltage (I_C = 350 mAdc, I_B = 35 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 350 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	30	pF

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%

TYPICAL CHARACTERISTICS

MPS6561 NPN **MPS6563 PNP**

FIGURE 1 – COLLECTOR SATURATION REGION



TYPICAL CHARACTERISTICS (continued)

MPS6561 NPN **MPS6563 PNP**

FIGURE 2 – DC CURRENT GAIN

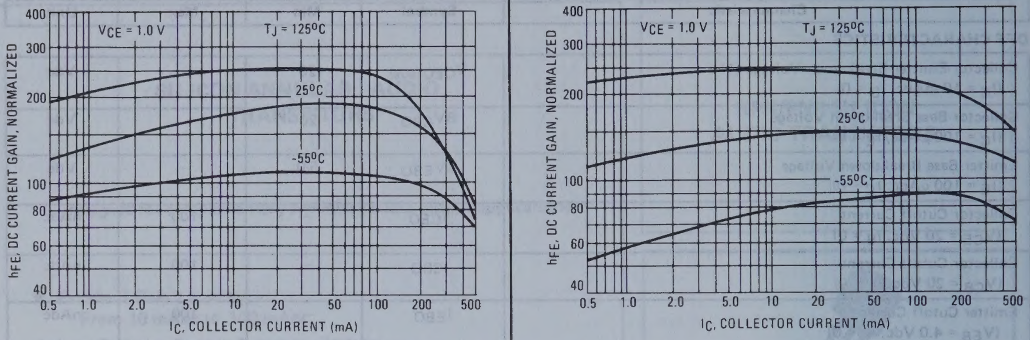


FIGURE 3 – "ON" VOLTAGE

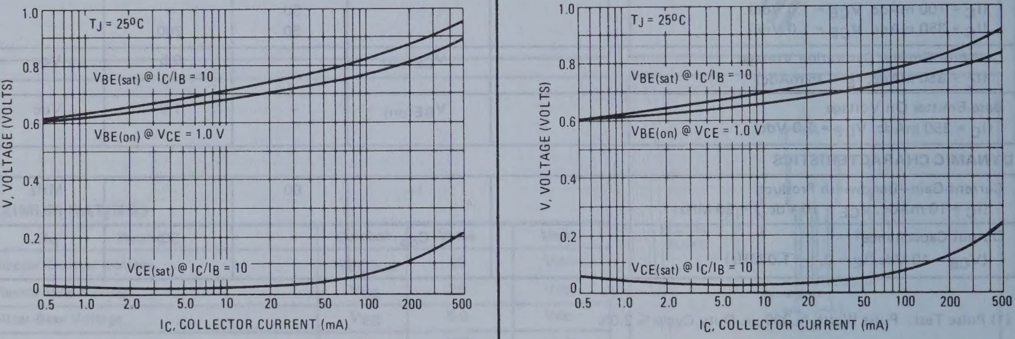
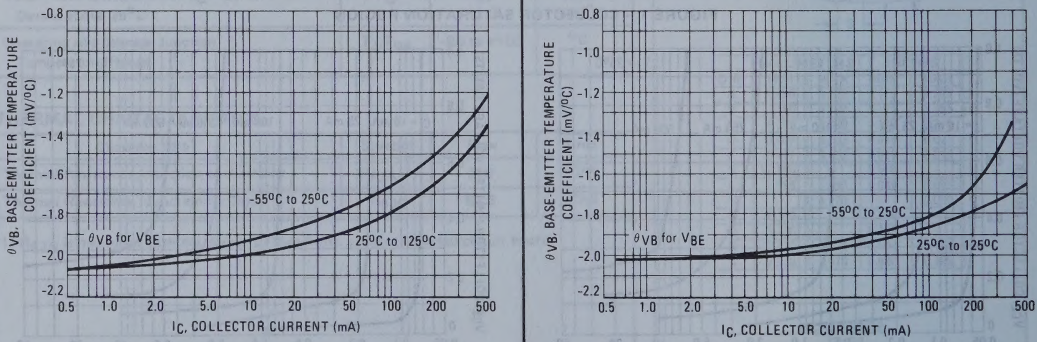


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT



TYPICAL CHARACTERISTICS

MPS6561 NPN **MPS6563 PNP**

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

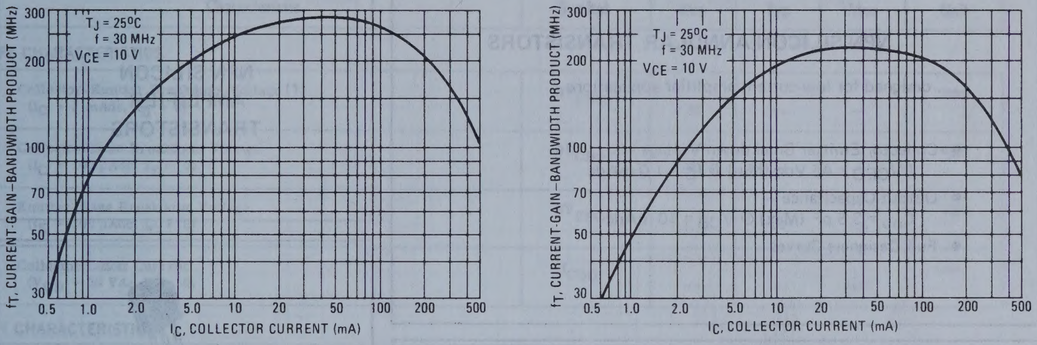
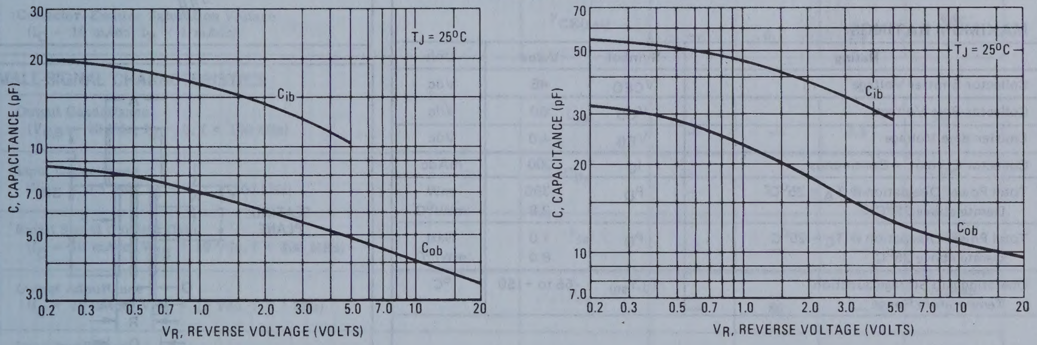


FIGURE 6 – CAPACITANCE



MPS6565 (SILICON)
MPS6566

NPN SILICON ANNULAR TRANSISTORS

. . . designed for low-current amplifier applications.

- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 45 Vdc (Min) @ I_C = 1.0 mAdc
- Output Capacitance –
  C_{ob} = 3.5 pF (Max) @ V_{CB} = 10 mAdc
- Full Designers Curves

NPN SILICON AMPLIFIER TRANSISTORS

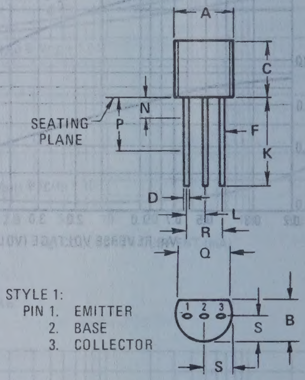
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc) MPS6565	h_{FE}	40	—	160	—
MPS6566		100	—	400	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.1	0.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	3.7	—	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	2.0	—	—	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{oe}	—	60	—	μmhos
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{ie}	—	500	—	ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{re}	—	2.5	—	$\times 10^{-4}$
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1000 ohms, f = 10 Hz to 15.7 kHz)	NF	—	4.0	—	dB

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5 Vdc, T_A = 25°C

FIGURE 1 — FREQUENCY EFFECTS

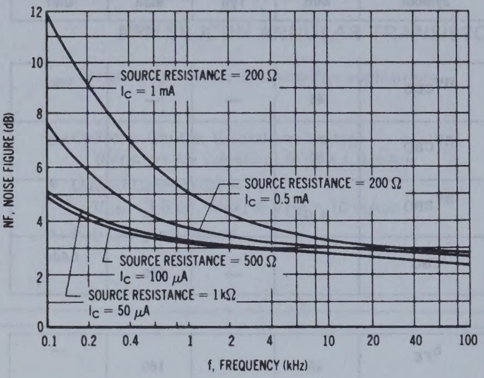
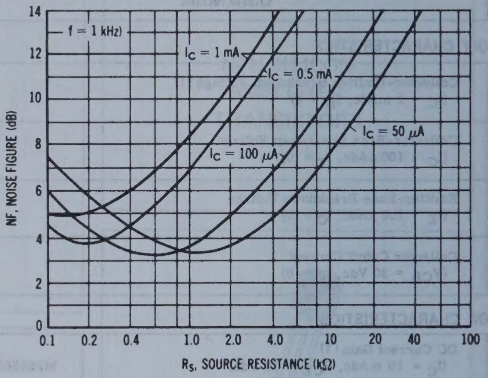


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 3 — CURRENT GAIN

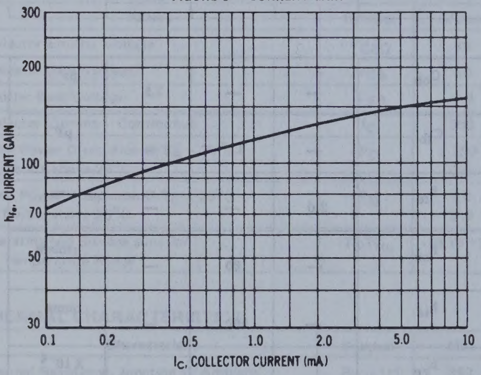


FIGURE 4 — OUTPUT ADMITTANCE

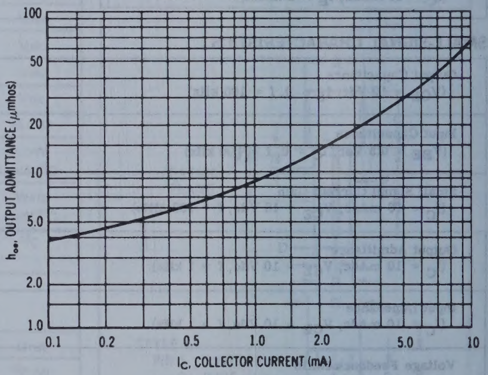


FIGURE 5 — INPUT IMPEDANCE

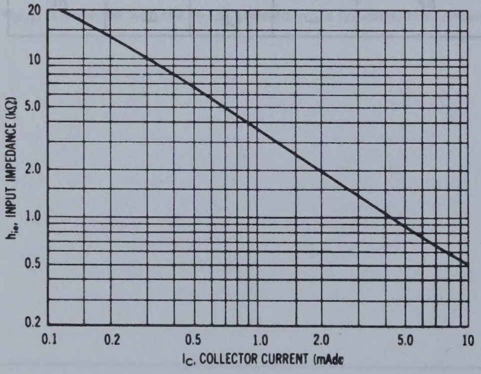
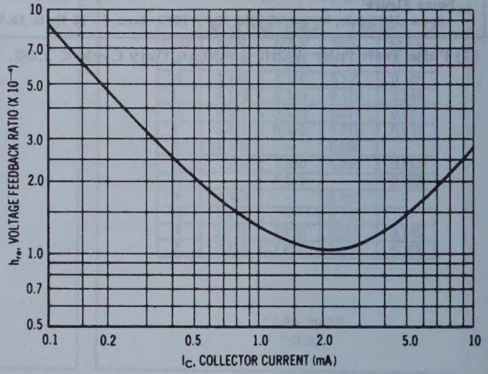


FIGURE 6 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 7 — NORMALIZED CURRENT GAIN

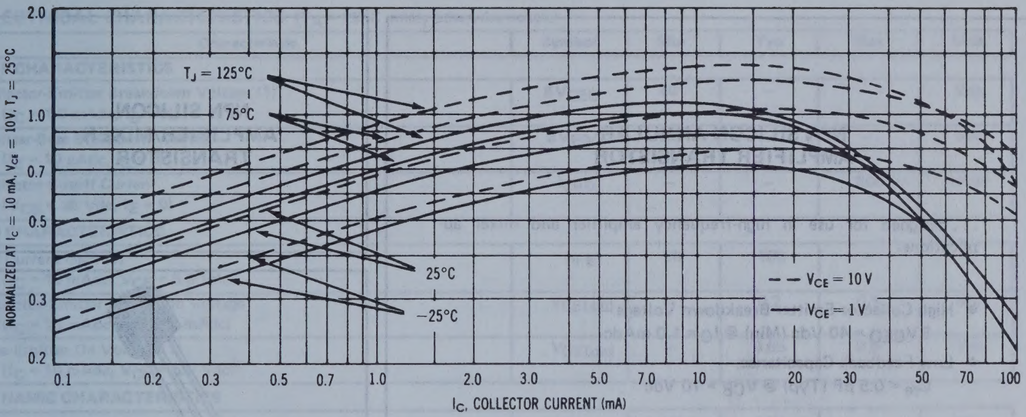


FIGURE 8 — COLLECTOR SATURATION REGION

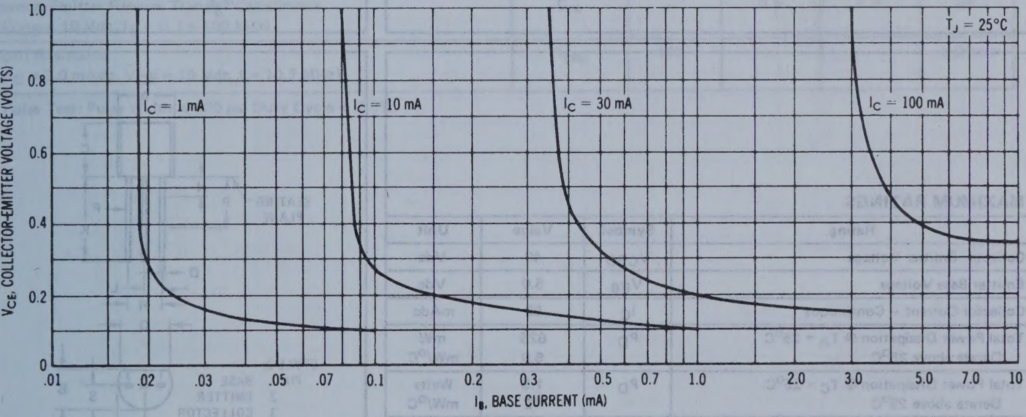


FIGURE 9 — TRANSCONDUCTANCE

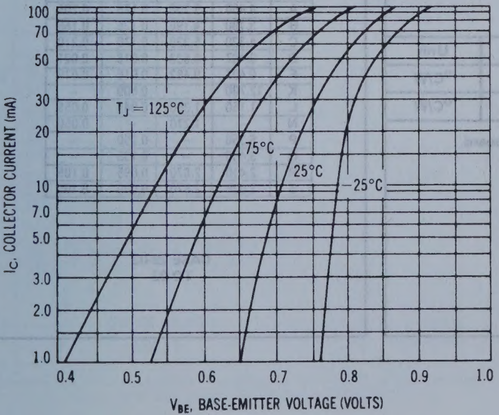
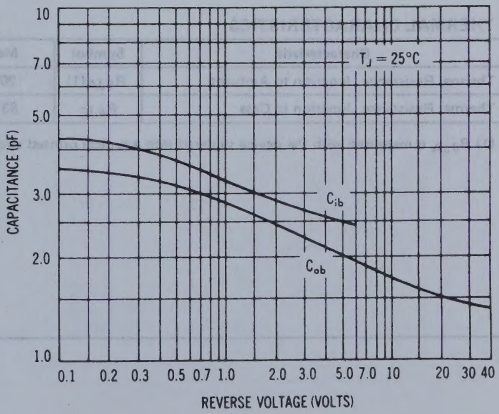


FIGURE 10 — CAPACITANCES



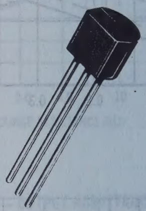
MPS6567 (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use in high-frequency amplifier and mixer applications.

- High Collector-Emitter Breakdown Voltage – BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Feedback Capacitance – C_{re} = 0.5 pF (Typ) @ V_{CB} = 10 Vdc

NPN SILICON AMPLIFIER/MIXER TRANSISTOR



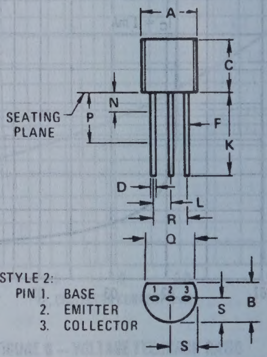
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	–	–	500	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	25	100	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.2	0.5	Vdc
Base-Emitter On Voltage (1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.65	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	800	–	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{re}	–	0.5	0.7	pF
Output Resistance (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 10.7 MHz)	R_{oep}	100	–	–	k Ohms

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

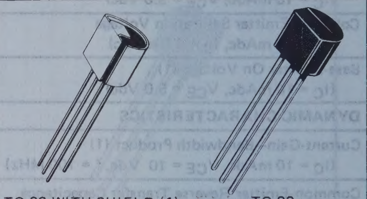
MPS6568, A (SILICON)
thru
MPS6570, A

NPN SILICON ANNULAR TRANSISTORS

. . . designed for VHF-RF and video IF stages in TV receivers.

- Guaranteed Noise Figure
  NF = 3.3 dB(Max) @ 200 MHz–MPS6568,A
  6.0 dB(Max) @ 45 MHz–MPS6569,A, MPS6570,A
- Guaranteed AGC Characteristics
- External Shielding for Optimum RF Circuit Performance
- Complete y-Parameter Curves at Both 45 MHz and 200 MHz
- Guaranteed Power Gain
  G_{pe} = 20 dB(Min) @ 200 MHz–MPS6568,A
  22.5 dB(Min) (Unneutralized) @ 45 MHz–MPS6529,A, MPS6570,A

NPN SILICON
VHF TRANSISTORS



TO-92 WITH SHIELD (1)	TO-92
MPS6568	MPS6568A
MPS6569	MPS6569A
MPS6570	MPS6570A

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Power Dissipation $T_A = 25^\circ C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ $T_C = 25^\circ C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

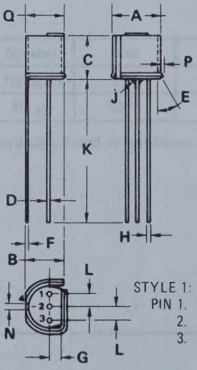
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (2)	$R_{\theta JC}$	125	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

(1) Device and shield supplied without shield being attached.
(2) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.03	5.18	0.198	0.204
B	4.01	4.27	0.158	0.168
C	4.45	4.70	0.175	0.185
D	0.254	0.381	0.010	0.015
E	30° TYP		30° TYP	
F	0.229	0.279	0.009	0.011
G	1.14	1.40	0.045	0.055
H	0.406	0.483	0.016	0.019
J	0.787 RAD		0.031 RAD	
K	12.70	–	0.500	–
L	1.27 T.P		0.050 T.P	
N	0.330	0.331	0.013	0.015
P	0.254 TYP		0.010 TYP	
Q	4.01	4.27	0.158	0.168

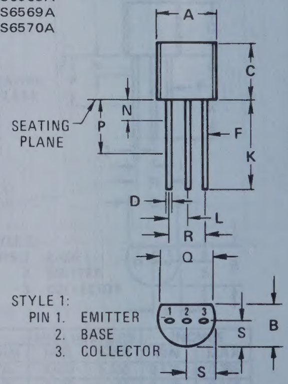
MPS6568
MPS6569
MPS6570



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 29A
TO-92

MPS6568A
MPS6569A
MPS6570A



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_C = 0)	I_{CBO}	–	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	200	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T			MHz
MPS6568A		375	800	
MPS6569A, MPS6570A		300	800	
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded, with shield)	C_{cb}			pF
MPS6568/6570		0.25	0.5	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded) MPS6568A/6570A		–	0.65	
Noise Figure (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9)	NF			dB
MPS6568,A		–	3.3	
(V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 10) MPS6569A, MPS6570A		–	6.0	
FUNCTIONAL TEST				
Power Gain (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9)	G_{pe}			dB
MPS6568,A		20	27	
(V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 10) MPS6569,A, MPS6570,A		22.5	28.5	
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 200 MHz, Figure 9)	V_{AGC}			Vdc
MPS6568,A		4.0	5.0	
(Gain Reduction = 30 dB, R_S = 50 ohms, f = 45 MHz, Figure 10) MPS6569,A		4.4	5.4	
MPS6570,A		5.2	6.2	

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 OHMS, SEE FIGURES 9 AND 10

—— f = 45 MHz – – f = 200 MHz

FIGURE 1 — POWER GAIN

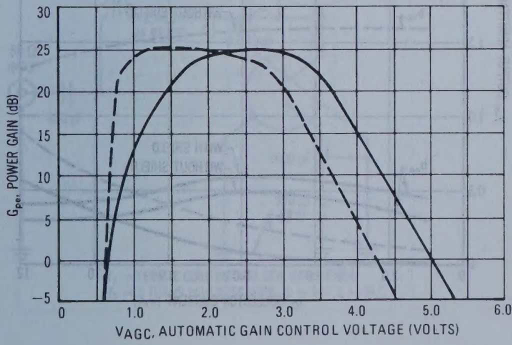
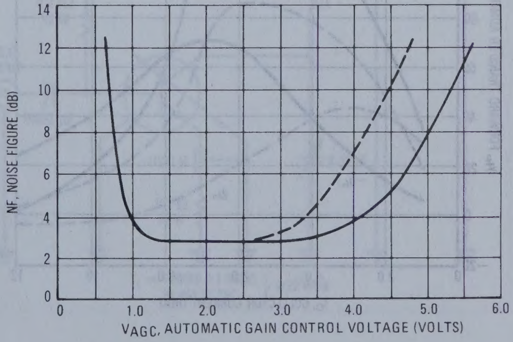


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C

—— f = 45 MHz – – – f = 200 MHz

FIGURE 3 — INPUT ADMITTANCE

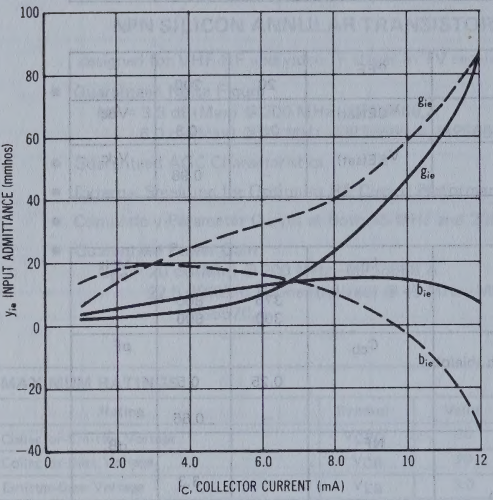


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

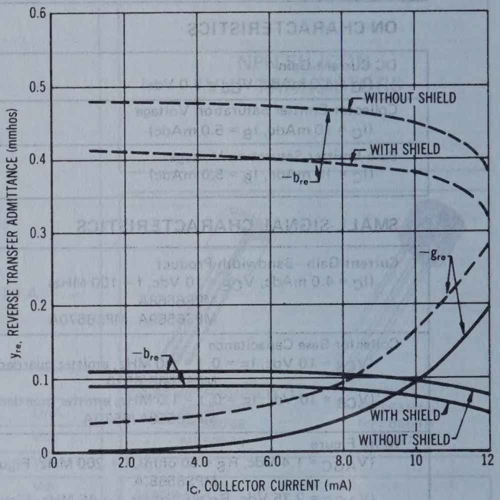


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

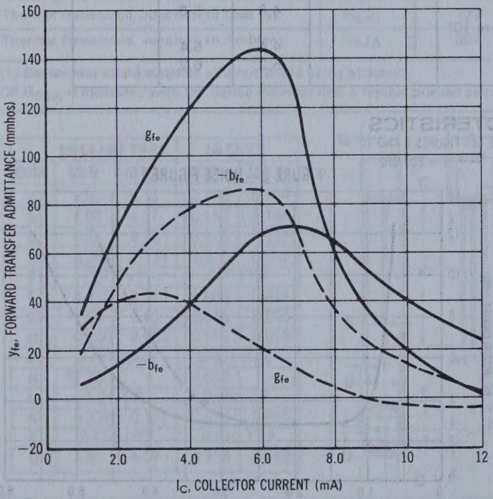


FIGURE 6 — OUTPUT ADMITTANCE

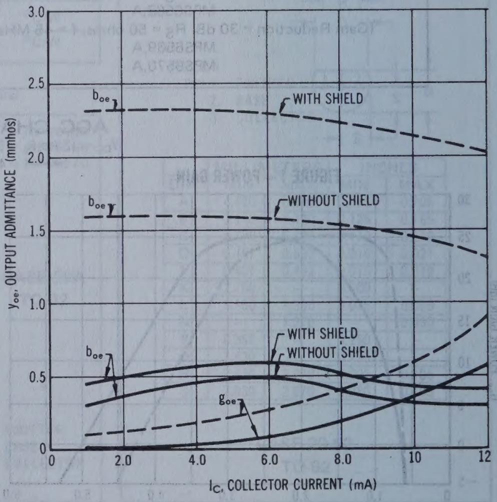


FIGURE 7 — DC CURRENT GAIN

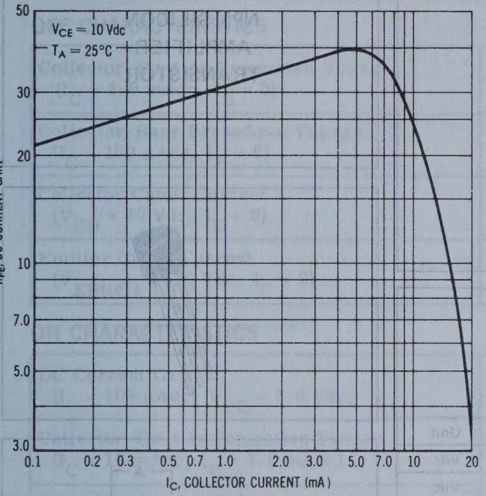


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

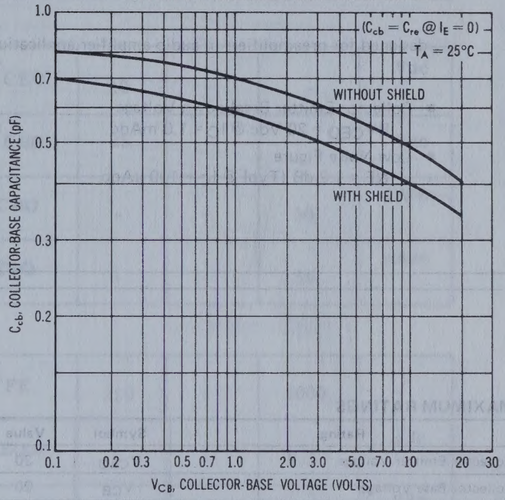
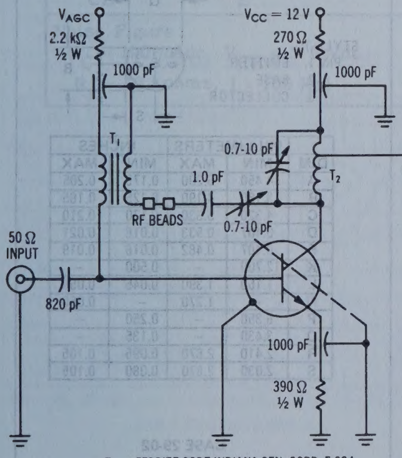
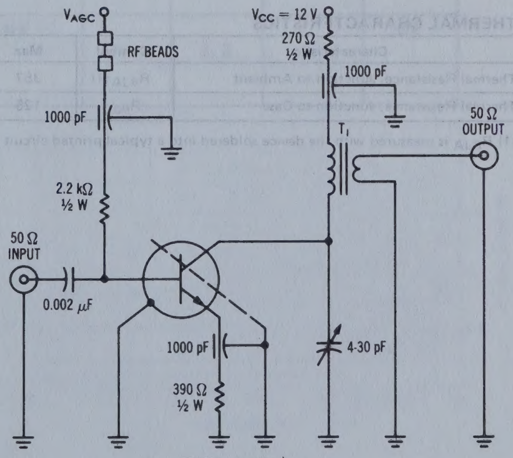


FIGURE 9 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)


V_{AGC}
2.2 kΩ
½ W
1000 pF
T_1
RF BEADS
50 Ω
INPUT
820 pF
V_{CC} = 12 V
270 Ω
½ W
1000 pF
0.7-10 pF
1.0 pF
0.7-10 pF
T_2
820 pF
50 Ω
OUTPUT
1000 pF
390 Ω
½ W

T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼", L = ¾".

FIGURE 10 — 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)


V_{AGC}
RF BEADS
1000 pF
2.2 kΩ
½ W
50 Ω
INPUT
0.002 µF
1000 pF
390 Ω
½ W
V_{CC} = 12 V
270 Ω
½ W
1000 pF
T_1
50 Ω
OUTPUT
4-30 pF

T_1 = TOROID 4:1 RATIO 8T-PRI 2T-SEC } #22 WIRE

MPS6571 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for preamplifiers in audio amplifier applications.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 20 Vdc @ I_C = 1.0 mAdc
- Low Noise Figure —
  NF = 1.2 dB (Typ) @ I_C = 100 μAdc

NPN SILICON AMPLIFIER TRANSISTOR

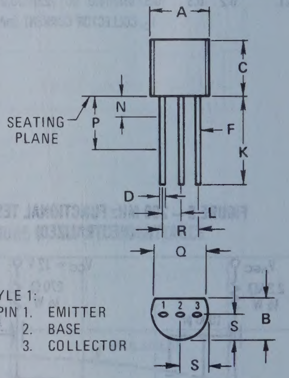
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0)	I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	h_{FE}	250	-	1000	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On, Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	50	175	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	-	4.5	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_s = 10 kohms, f = 100 Hz)	NF	-	1.2	-	dB

FIGURE 1 — DC CURRENT GAIN

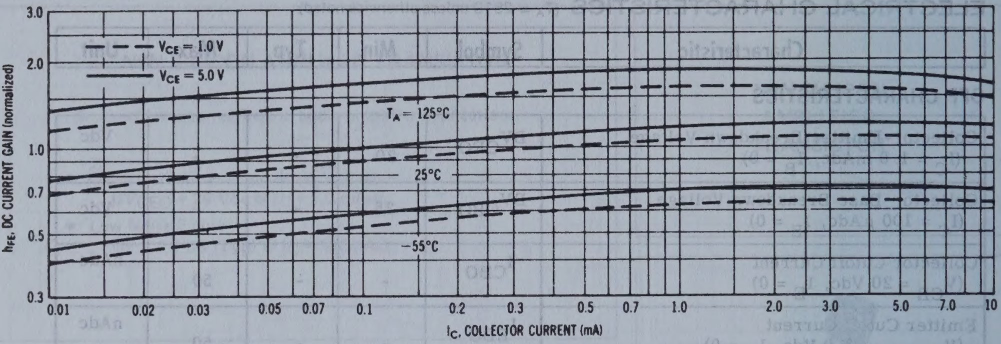


FIGURE 2 — CURRENT GAIN

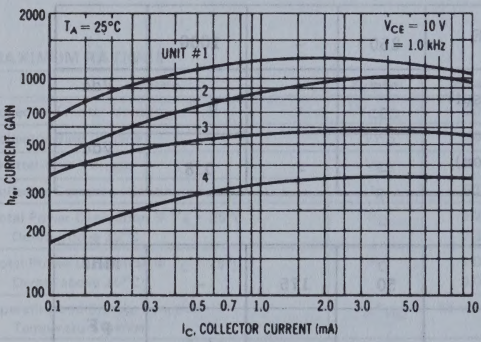
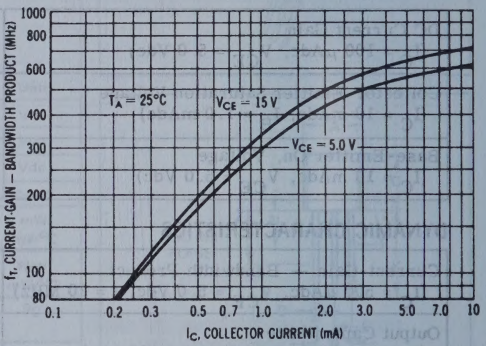


FIGURE 3 — CURRENT GAIN — BANDWIDTH PRODUCT



NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 4 — FREQUENCY EFFECTS

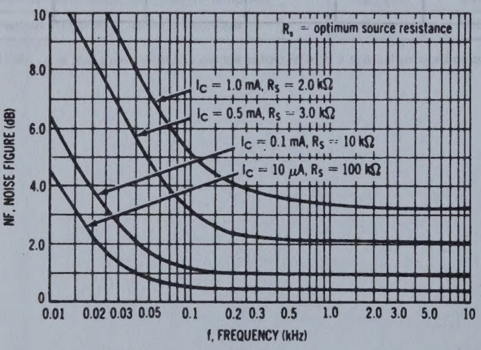
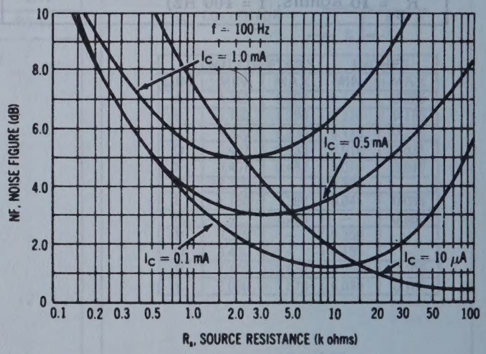


FIGURE 5 — SOURCE RESISTANCE EFFECTS



MPS6573 (SILICON)
thru
MPS6576

NPN SILICON ANNULAR TRANSISTORS

. . . designed for audio amplifier applications.

- DC Current Gain Specified for Audio Predriver Design – 100 μAdc to 10 mAdc for MPS6573 and MPS6575
- DC Current Gain to Facilitate Differential Amplifier Design for Audio Input Stages – Grouping at 1.0 mAdc for MPS6574 and MPS6576
- Current-Gain – Bandwidth Product – f_T = 200 MHz (Max) for Audio Frequency Design

NPN SILICON AUDIO TRANSISTORS

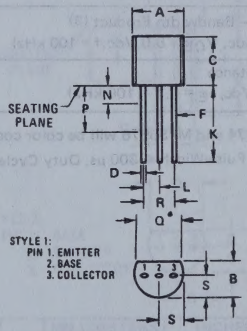
MAXIMUM RATINGS

Rating	Symbol	MPS6573 MPS6574	MPS6575 MPS6576	Unit
Collector-Emitter Voltage	V_{CEO}	35	45	Vdc
Collector-Base Voltage	V_{CB}	35	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	100		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the deviced soldered into a typical printed circuit board.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

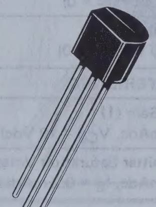
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (3)		BV_{CEO}			Vdc
(I_C = 1.0 mAdc, I_B = 0)	MPS6573,MPS6574		35	–	
	MPS6575,MPS6576		45	–	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 35 Vdc, I_E = 0)	MPS6573,MPS6574		–	100	
(V_{CB} = 45 Vdc, I_E = 0)	MPS6575,MPS6576		–	100	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 4.0 Vdc, I_C = 0)			–	100	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MPS6573,MPS6575		100	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (3)	MPS6573,MPS6575		200	500	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPS6574,MPS6576 (2)				
	Yellow		100	150	
	Blue		125	185	
	Green		150	225	
	Silver		200	300	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.5	
Base-Emitter On Voltage (3)		$V_{BE(on)}$			Vdc
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			–	0.8	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (3)		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 kHz)			100	350	
Output Capacitance		C_{ob}			pF
(V_{CB} = 12 Vdc, I_E = 0, f = 100 kHz)			–	12	

(2) The MPS6574 and MPS6576 will be color coded to identify DC Current Gain Categories.

(3) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

MPS6580 (SILICON)

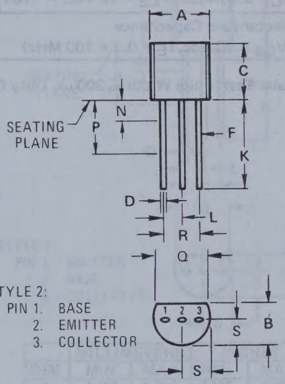
PNP SILICON RF AMPLIFIER TRANSISTOR



PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in general-purpose RF amplifier applications.

- High Collector Emitter Breakdown Voltage — BV_{CEO} = 25 Vdc (Min) @ I_C = 1.0 mAdc
- High Current-Gain—Bandwidth Product — f_T = 450 MHz (Typ) @ I_C = 2.0 mAdc



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	25	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current ($V_{BE} = 2.0$ Vdc, $I_C = 0$)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	20	80	–	–
Collector-Emitter Saturation Voltage ($I_C = 2.0$ mAdc, $I_B = 0.2$ mAdc)	$V_{CE(sat)}$	–	0.2	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	250	450	–	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 MHz)	C_{cb}	–	0.5	1.0	pF

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.

MPS8000 (SILICON)

NPN SILICON ANNULAR RF TRANSISTOR

. . . designed for use in Citizen-Band Communications equipment operating to 30 MHz. High current gain available for driver applications. This device is designed to be used with the MPS8001 RF oscillator and the MPS-U31 RF power output.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	83.3	$^oC/W$
Thermal Resistance, Junction to Ambient	$R\theta_{JC}$ (1)	200	$^oC/W$

(1) Typical printed circuit board mounting.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

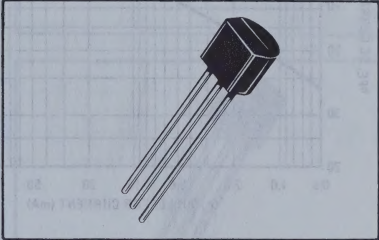
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (2) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	30	–	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (P_{out} = 350 mW, V_{CC} = 13.6 Vdc, f = 27 MHz)	G_{pe}	12	–	dB
Power Output (P_{in} = 21.8 mW, V_{CC} = 13.6 Vdc, f = 27 MHz)	P_{out}	350	–	mW

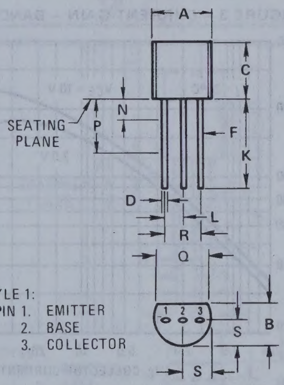
(2) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle = 2.0%.

625 mW – 27 MHz

RF DRIVER TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

TYPICAL CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

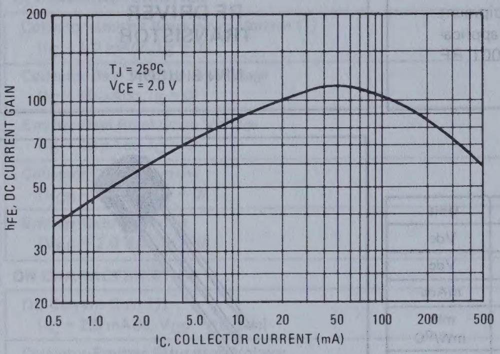


FIGURE 2 – ON VOLTAGES

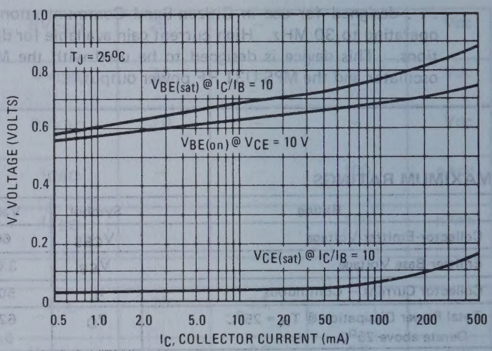


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

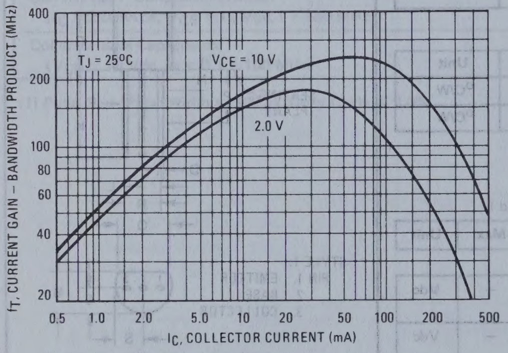


FIGURE 4 – CAPACITANCE

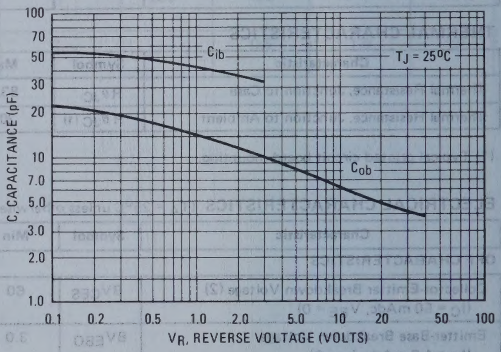
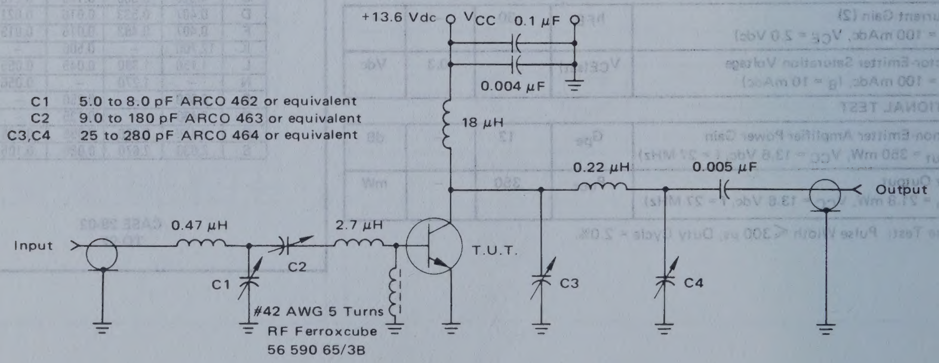


FIGURE 5 – 27 MHz TEST CIRCUIT



+13.6 Vdc
V_{CC}
0.1 μF
0.004 μF
18 μH
0.22 μH
0.005 μF
Output
Input
0.47 μH
2.7 μH
T.U.T.
C1
C2
C3
C4
#42 AWG 5 Turns
RF Ferroxcube
56 590 65/3B

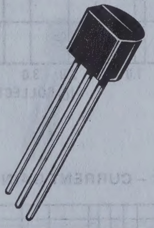
C1	5.0 to 8.0 pF ARCO 462 or equivalent
C2	9.0 to 180 pF ARCO 463 or equivalent
C3,C4	25 to 280 pF ARCO 464 or equivalent

MPS8001 (SILICON)

NPN SILICON RF ANNULAR TRANSISTOR

. . . designed for use in Citizen-Band communications equipment operating to 30 MHz, with low feedback capacity for stable operation. This part is designed to be used with the MPS8000 driver and the MPS-U31 RF power output.

RF OSCILLATOR
TRANSISTOR
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

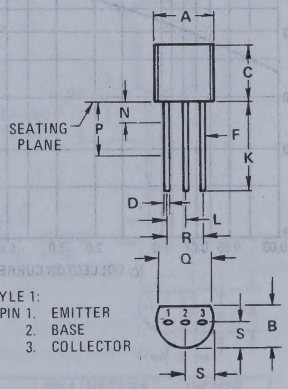
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	^oC/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$*	357	^oC/mW

*$R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	–	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ce}	–	0.65	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

FIGURE 1 – DC CURRENT GAIN

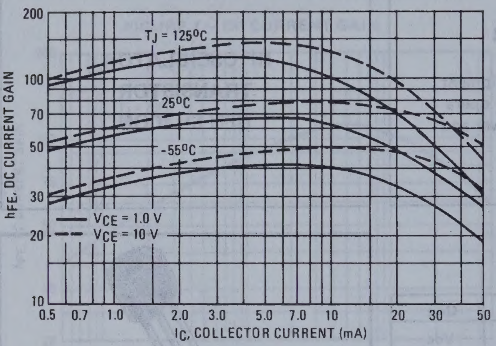


FIGURE 2 – "ON" VOLTAGE

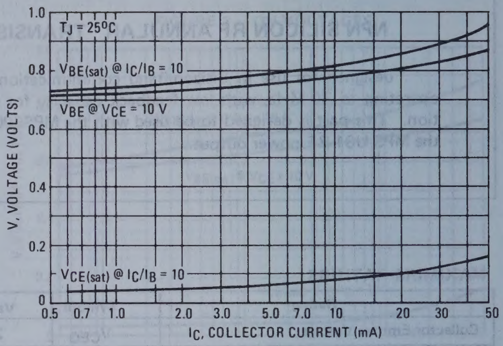


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

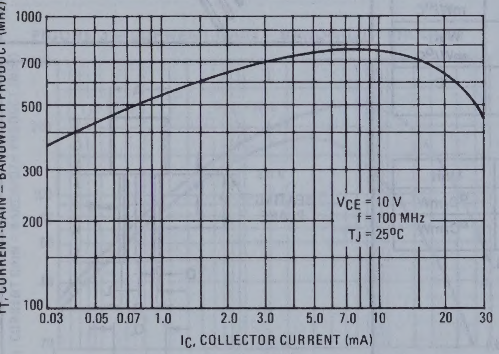
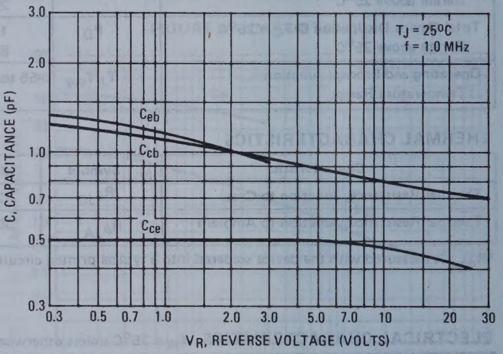


FIGURE 4 – CAPACITANCE



MPS8097 (SILICON)

NPN SILICON ANNULAR LOW-NOISE, HIGH-GAIN AMPLIFIER TRANSISTOR

. . . designed for use in low-level, low-noise amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- High DC Current Gain — h_{FE} = 250 (Min) @ I_C = 100 μAdc
- High Current-Gain — Bandwidth Product — f_T = 200 MHz (Min) @ I_C = 10 mAdc
- Low Noise Figure — NF = 2.0 dB (Max) @ I_C = 100 μAdc, f = 10 Hz to 15.7 kHz

NPN SILICON LOW NOISE, HIGH GAIN AMPLIFIER TRANSISTOR

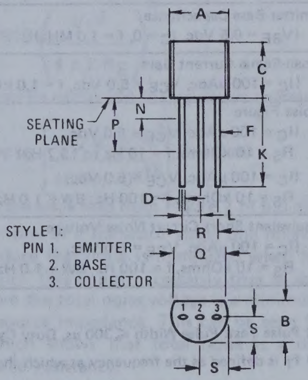
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

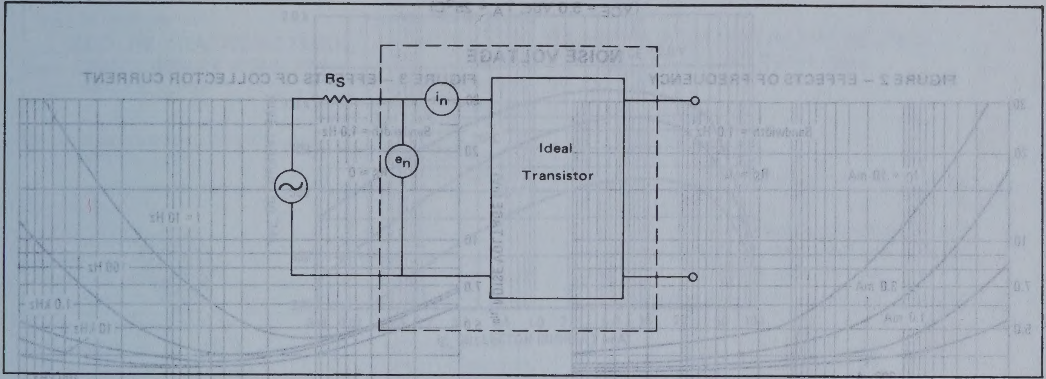
ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	BV_{CEO}	40	–	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$) ($V_{CB} = 60$ Vdc, $I_E = 0$)	I_{CBO}	 – –	 30 10	 nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 6.0$ Vdc, $I_C = 0$)	I_{EBO}	–	20	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	250	700	–
Base-Emitter on Voltage ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	0.45	0.65	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	f_T	200	–	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	1.0	4.0	pF
Emitter-Base Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 1.0 MHz)	C_{eb}	–	10	pF
Small-Signal Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, f = 1.0 kHz)	h_{fe}	250	800	–
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kOhms, f = 10 Hz to 15.7 Hz) ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kOhms, f = 100 Hz, BW = 1.0 Hz)	NF	 – –	 2.0 8.0	dB
Equivalent Short Circuit Noise Voltage ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kOhms, f = 100 Hz, BW = 1.0 Hz)	V_T	–	32	$nV/\sqrt{Hz}$

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extropolates to unity.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE APPLICATION NOTE

For a transistor, total noise at the input may be expressed as:

$$V_T = \left[e_n^2 + 4KT\,R_S + i_n^2\,R_S^2 \right]^{\frac{1}{2}} \qquad (1)$$

(See Figure 1)

Where:

V_T = total noise voltage at the transistor input (Volts/$\sqrt{\text{Hz}}$)

e_n = noise voltage of the transistor referred to the input (Figures 2 and 3)

i_n = noise current of the transistor referred to the input (Figure 4)

K = Boltzman's constant (1.38×10^{-23} j/°K)

T = temperature of the source resistance (°K)

R_S = source resistance (Ohms)

Example:

Find the total noise at the input of an MPS-8097 for a collector current of 1.0 mA and a source impedance of 1.0 Kilohm at a frequency of 100 Hz and at a temperature of 25°C.

Read e_n = 4.6 nV/$\sqrt{\text{Hz}}$ from Figure 2 or Figure 3. (Note that this is for a one cycle bandwidth)

Read i_n = 3.6 pA/$\sqrt{\text{Hz}}$ from Figure 4.

$$V_T = \left[(4.6 \times 10^{-9})^2 + (4)(1.38 \times 10^{-23})(300)(1 \times 10^3) + (3.6 \times 10^{-12})^2\,(1 \times 10^3)^2 \right]^{\frac{1}{2}} = 7.2\ \text{nV}/\sqrt{\text{Hz}}$$

This checks with the value shown in Figure 6.

Example:

Read V_T = 7.2 nV/$\sqrt{\text{Hz}}$ at I_C = 1.0 mA and R_S = 1.0 kΩ.

Noise figure is defined as:

$$NF = 20 \log_{10} \frac{\text{total noise voltage}}{\text{noise voltage contributed by the Source Resistance}}$$

or

$$NF = 20 \log_{10} \left(\frac{V_T^2}{4\,KT\,R_S} \right)^{\frac{1}{2}} \qquad (2)$$

Noise figure can be calculated for the above example as follows:

$$NF = 20 \log_{10} \left[\frac{(7.2 \times 10^{-9})^2}{16.6 \times 10^{-18}} \right]^{\frac{1}{2}} = 4.9\ \text{dB}$$

This checks with the value read from Figure 7 of 5.0 dB.

To minimize noise in a transistor stage, one might use Figure 7 and deduce that noise is minimized when Noise Figure is minimum. This is not necessarily true as shown by Figure 6 where the total noise voltage is a minimum at small values of source impedance. This can be seen from equation (1) which shows that total noise is a direct function of source resistance.

Noise over a frequency band can be handled in one of two ways depending upon whether total transistor noise is constant or variable over the bandwidth of interest:

1. For Constant transistor noise, multiply, V_T by the square root of bandwidth, i.e., $V_T' = V_T \bullet \Delta f^{\frac{1}{2}}$
2. For variable transistor noise, plot V_T (where Δf = 1.0 Hz) versus frequency over the bandwidth and integrate the result.

Total noise voltage at the output of the transistor stage can be found by multiplying V_T or V_T' by the voltage gain of the stage.

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

FIGURE 2 – EFFECTS OF FREQUENCY

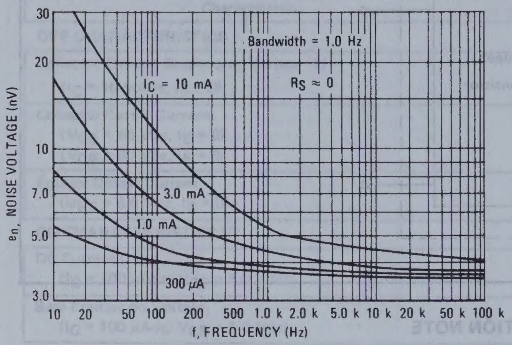


FIGURE 3 – EFFECTS OF COLLECTOR CURRENT

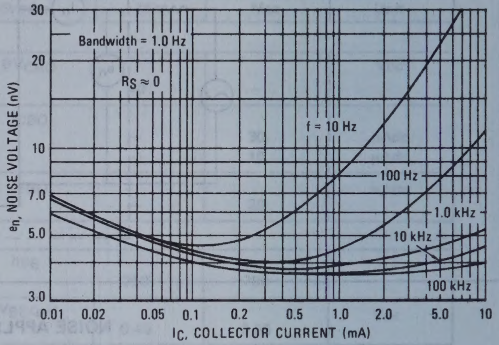


FIGURE 4 – NOISE CURRENT

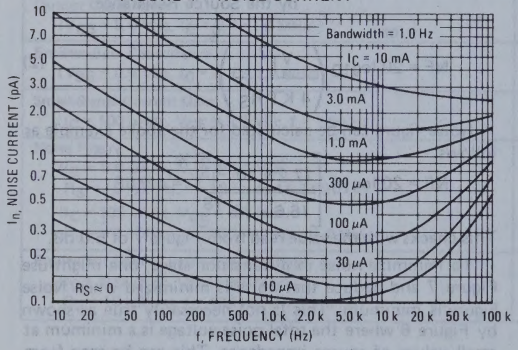
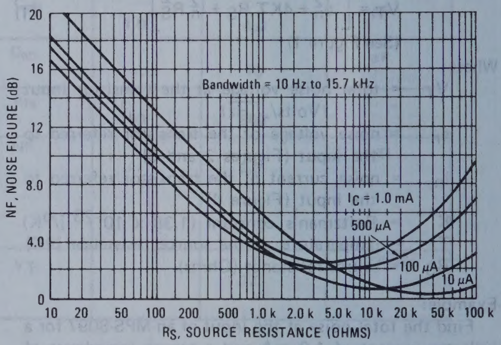


FIGURE 5 – WIDEBAND NOISE FIGURE



100 Hz NOISE DATA

FIGURE 6 – TOTAL NOISE VOLTAGE

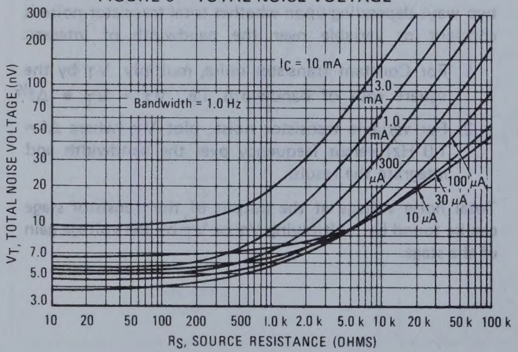


FIGURE 7 – NOISE FIGURE

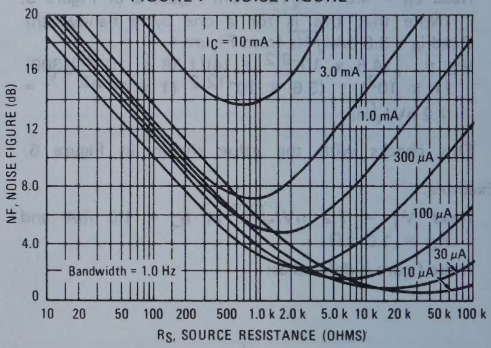


FIGURE 8 – DC CURRENT GAIN

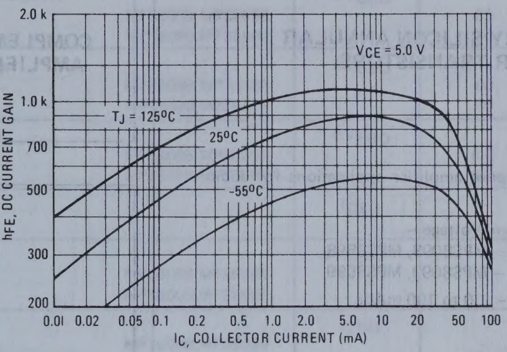


FIGURE 9 – "ON" VOLTAGES

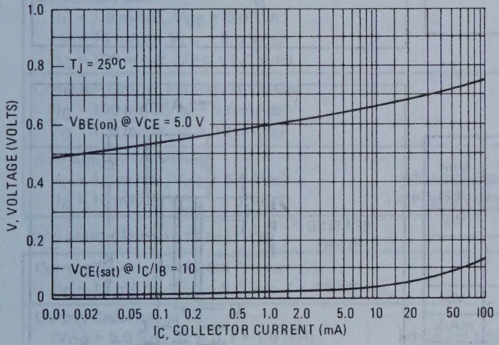


FIGURE 10 – TEMPERATURE COEFFICIENTS

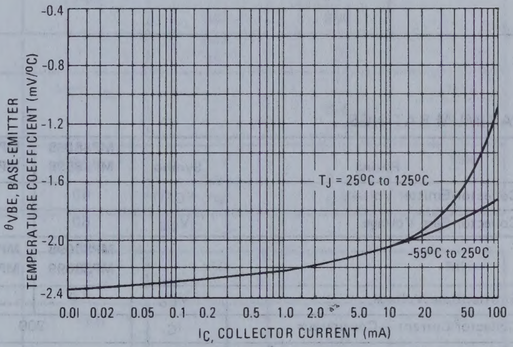


FIGURE 11 – CAPACITANCE

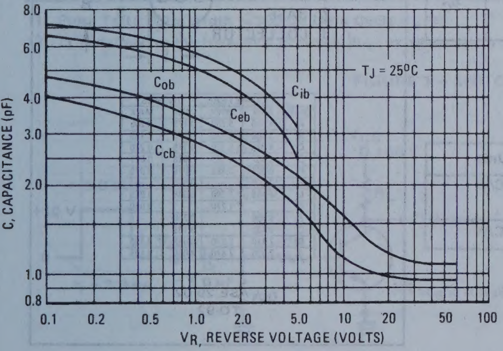
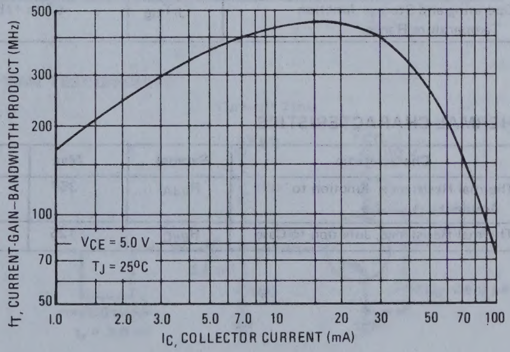


FIGURE 12 – CURRENT-GAIN–BANDWIDTH PRODUCT



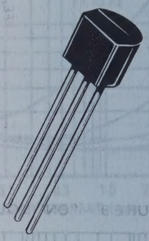
MPS8098, MPS8099NPN (SILICON)
MPS8598, MPS8599PNP

COMPLEMENTARY SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose amplifier applications for audio circuits.

- Collector Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) -- MPS8098, MPS8598
  80 Vdc (Min) – MPS8099, MPS8599
- DC Current Gain Specified – 1.0 to 100 mAdc

COMPLEMENTARY SILICON AMPLIFIER TRANSISTORS

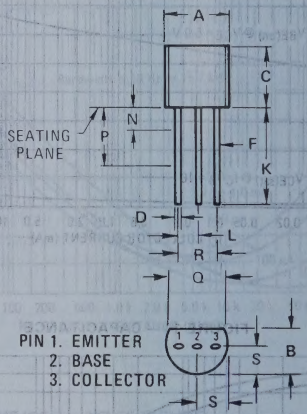


MAXIMUM RATINGS

Rating	Symbol	MPS8098 MPS8598	MPS8099 MPS8599	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
		MPS8098 MPS8099	MPS8598 MPS8599	
Emitter-Base Voltage	V_{EB}	6.0	5.0	Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8		mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0		Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

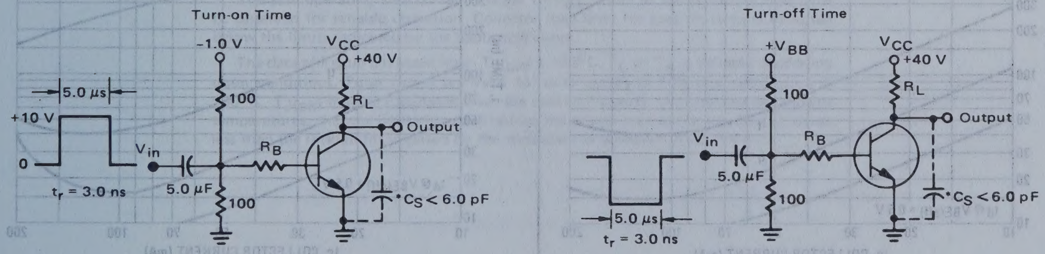
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}			Vdc
(I_C = 10 mAdc, I_B = 0)	MPS8098,MPS8598		60	—	
	MPS8099,MPS8599		80	—	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 µAdc, I_E = 0)	MPS8098 MPS8598		60	—	
	MPS8099,MPS8599		80	—	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 µAdc, I_C = 0)	MPS8098,MPS8099		6.0	—	
	MPS8598,MPS8599		5.0	—	
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	—	0.1	µAdc
Collector Cutoff Current		I_{CBO}			µAdc
(V_{CB} = 60 Vdc, I_E = 0)	MPS8098,MPS8598		—	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	MPS8099,MPS8599		—	0.1	
Emitter Cutoff Current		I_{EBO}			µAdc
(V_{EB} = 6.0 Vdc, I_C = 0)	MPS8098,MPS8099		—	0.1	
(V_{EB} = 5.0 Vdc, I_C = 0)	MPS8598,MPS8599		—	0.1	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			100	300	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			100	—	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)			75	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 5.0 mAdc)			—	0.4	
(I_C = 100 mAdc, I_B = 10 mAdc)			—	0.3	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MPS8098,MPS8598		0.5	0.7	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS8099,MPS8599		0.6	0.8	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	150	—	MHz
Output Capacitance		C_{ob}			pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	MPS8098,MPS8099		—	6.0	
	MPS8598,MPS8599		—	8.0	
Input Capacitance		C_{ib}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	MPS8098,MPS8099		—	25	
	MPS8598,MPS8599		—	30	

(1) Pulse Test: Pulse Width ⩽300 µs, Duty Cycle = 2.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS



*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

NPN
MPS8098,MPS8099

PNP
MPS8598,MPS8599

FIGURE 2 – CURRENT-GAIN – BANDWIDTH PRODUCT

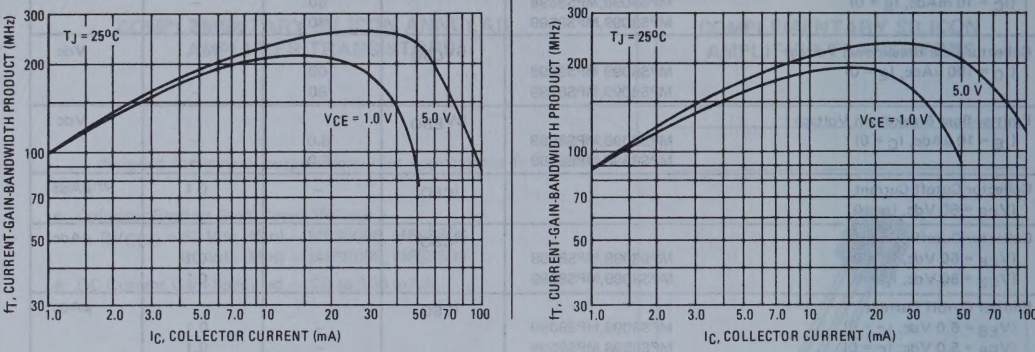


FIGURE 3 – CAPACITANCE

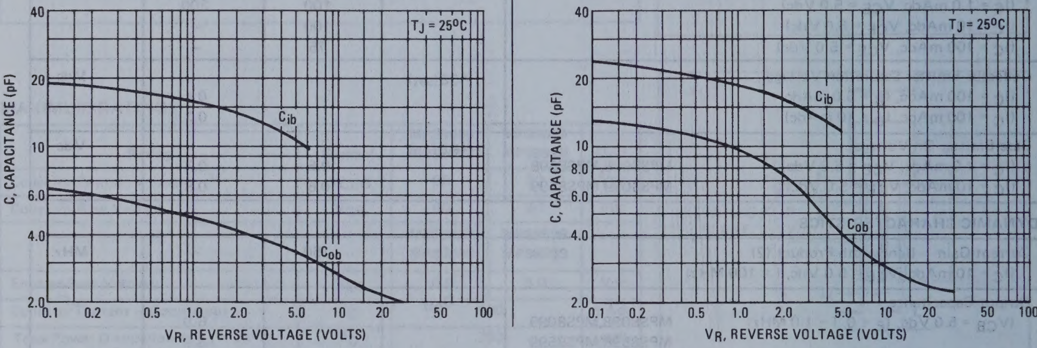


FIGURE 4 – SWITCHING TIMES

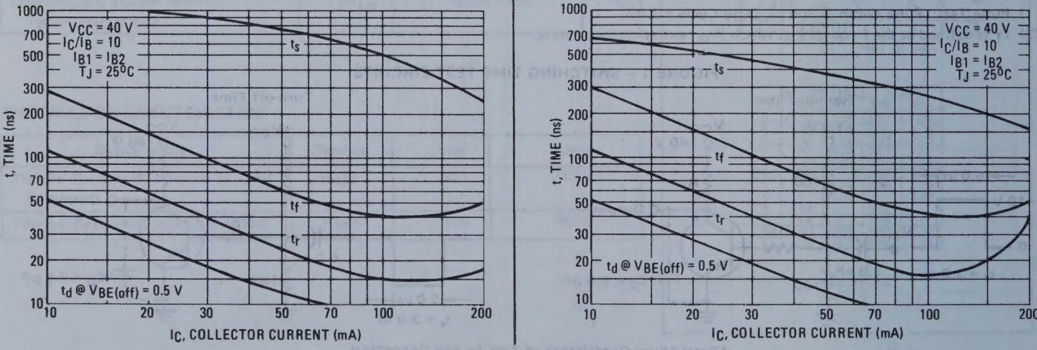


FIGURE 5 — THERMAL RESPONSE

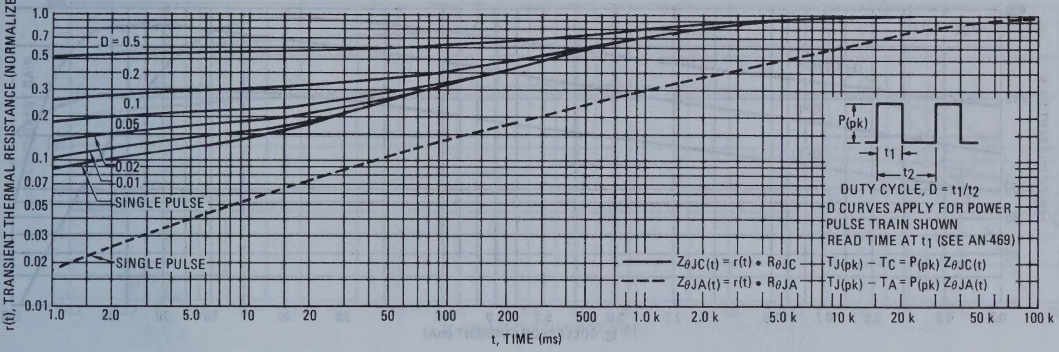
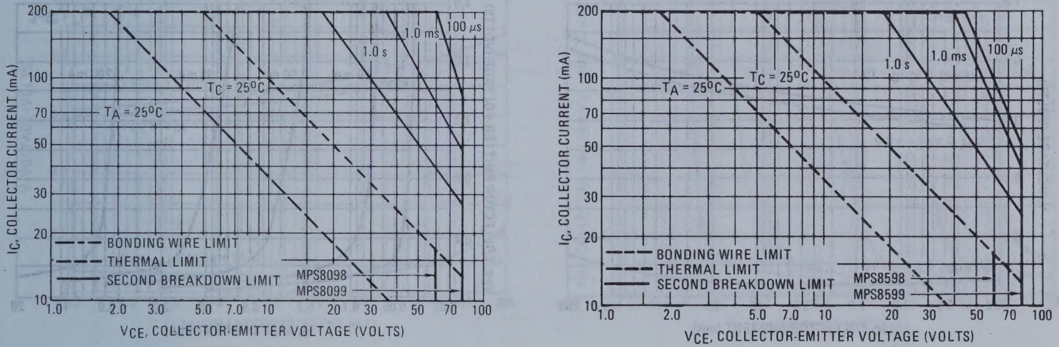


FIGURE 6 — ACTIVE-REGION SAFE OPERATING AREA


MPS8098, MPS8099

MPS8598, MPS8599

The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 6 is based upon $T_{J(pk)} = 150^{\circ}C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 5. At high case or ambient temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown. (See AN-415)

NPN
MPS8098, MPS8099

FIGURE 7 – DC CURRENT GAIN

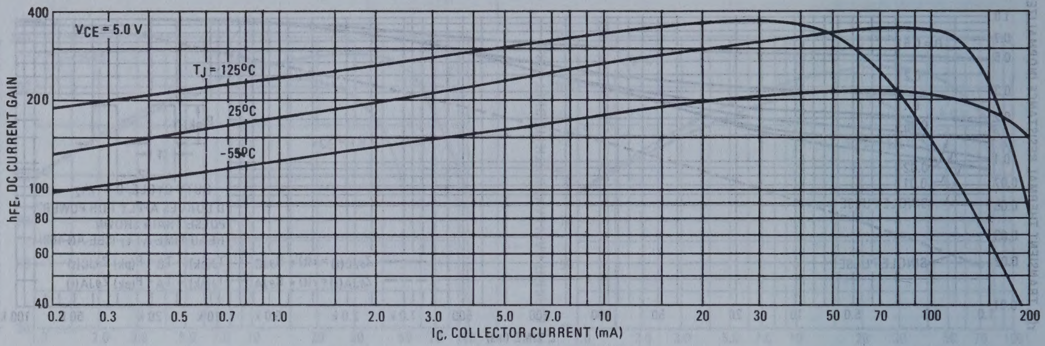


FIGURE 8 – "ON" VOLTAGES

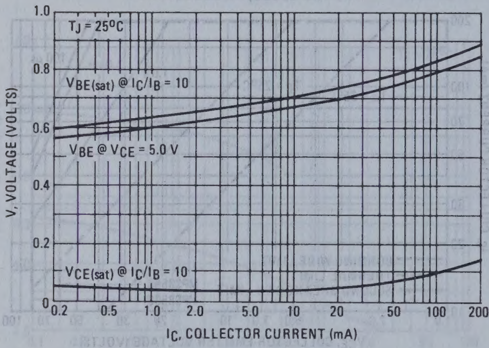


FIGURE 9 – COLLECTOR SATURATION REGION

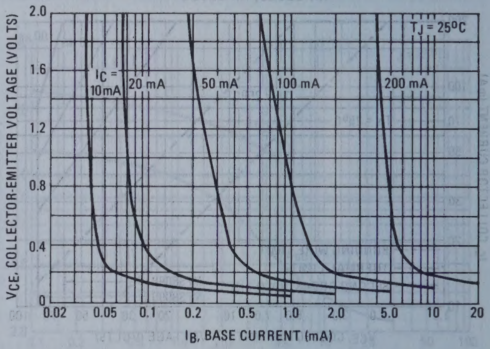
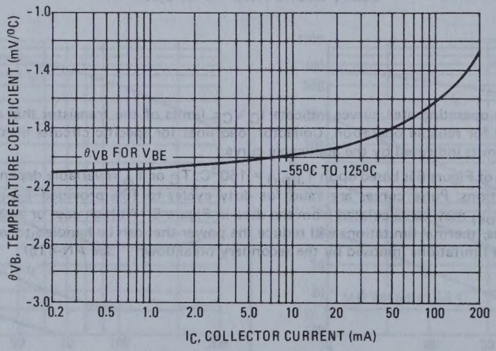


FIGURE 10 – BASE-EMITTER TEMPERATURE COEFFICIENT



PNP
MPS8598, MPS8599

FIGURE 11 – DC CURRENT GAIN

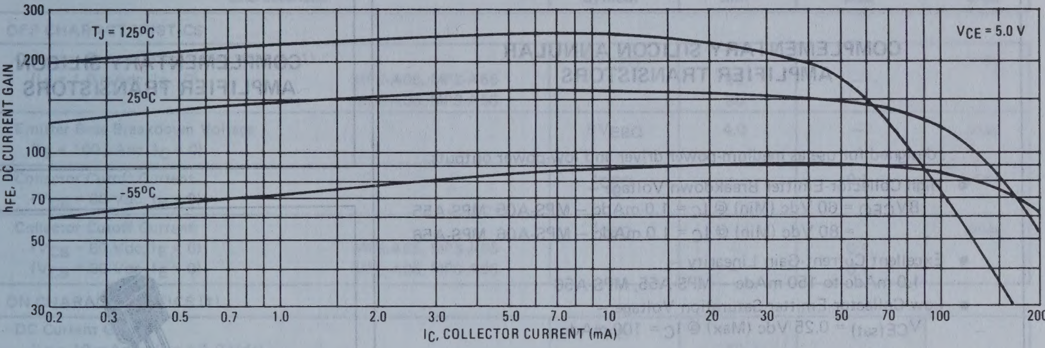


FIGURE 12 – "ON" VOLTAGES

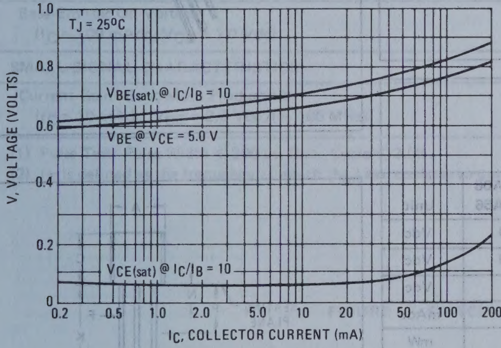


FIGURE 13 – COLLECTOR SATURATION REGION

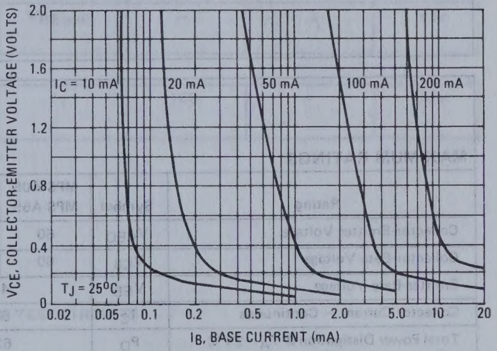
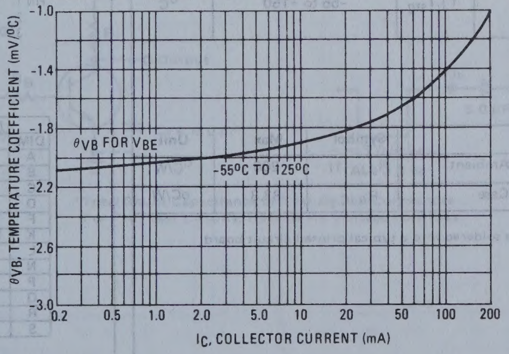


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



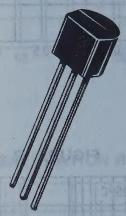
MPS-A05, MPS-A06NPN (SILICON)
MPS-A55, MPS-A56PNP

COMPLEMENTARY SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for use as medium-power driver and low-power outputs.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-A05, MPS-A55
  = 80 Vdc (Min) @ I_C = 1.0 mAdc – MPS-A06, MPS-A56
- Excellent Current-Gain Linearity –
  1.0 mAdc to 150 mAdc – MPS-A55, MPS-A56
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 100 mAdc

COMPLEMENTARY SILICON AMPLIFIER TRANSISTORS



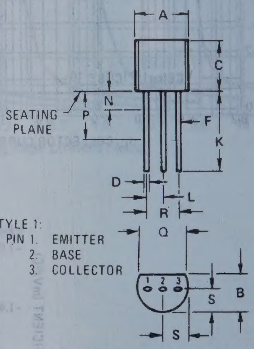
MAXIMUM RATINGS

Rating	Symbol	MPS-A05 MPS-A55	MPS-A06 MPS-A56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0		mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12		Watts mW/^oC
Operating and Storage Temperature Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	200	^oC/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	oC/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

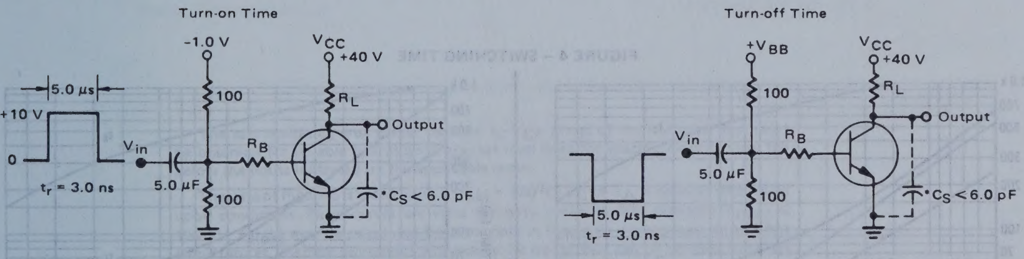
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B - 0)	 MPS-A05, MPS-A55 MPS-A06, MPS-A56	BV_{CEO}	 60 80	 – –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)		I_{CEO}	–	0.1	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	 MPS-A05, MPS-A55 MPS-A06, MPS-A56	I_{CBO}	 – –	 0.1 0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 50 50	 – –	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	–	0.25	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		f_T	100	–	MHz

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS


Turn-on Time
-1.0 V
V_{CC}
+40 V
5.0 μs
+10 V
0
100
R_L
Output
V_{in}
R_B
t_r = 3.0 ns
5.0 μF
100
*C_S < 6.0 pF
Turn-off Time
$+V_{BB}$
V_{CC}
+40 V
100
R_L
Output
V_{in}
R_B
5.0 μF
100
*C_S < 6.0 pF
5.0 μs
t_r = 3.0 ns

*Total Shunt Capacitance of Test Jig and Connectors
For PNP Test Circuits, Reverse All Voltage Polarities

NPN
MPS-A05, MPS-A06

PNP
MPS-A55, MPS-A56

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

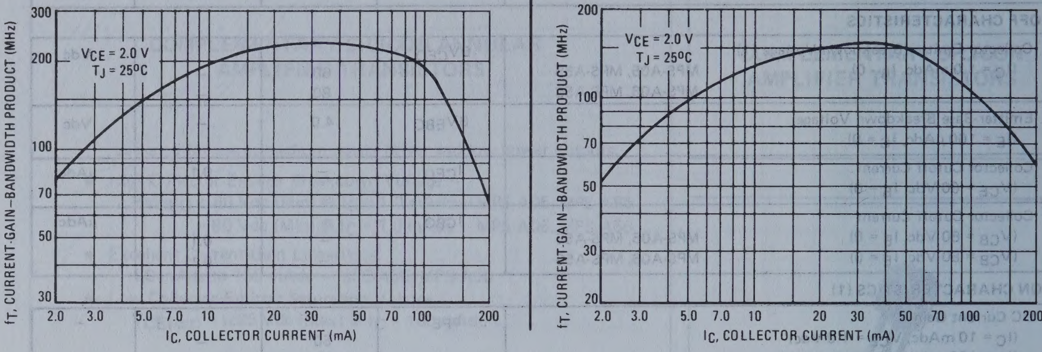


FIGURE 3 – CAPACITANCE

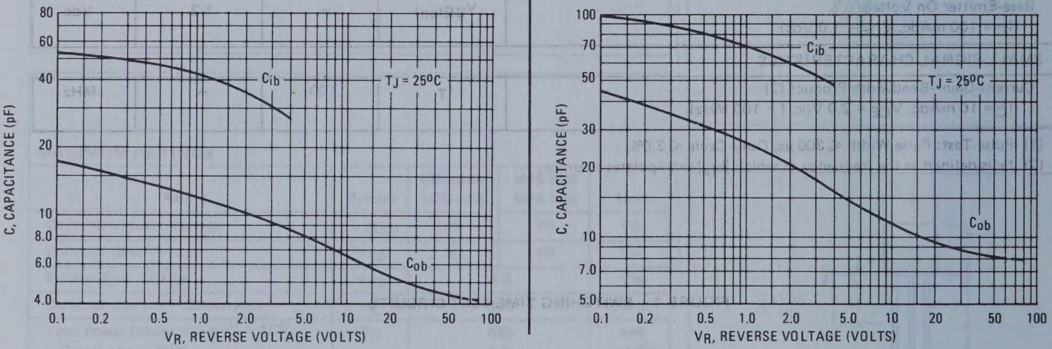


FIGURE 4 – SWITCHING TIME

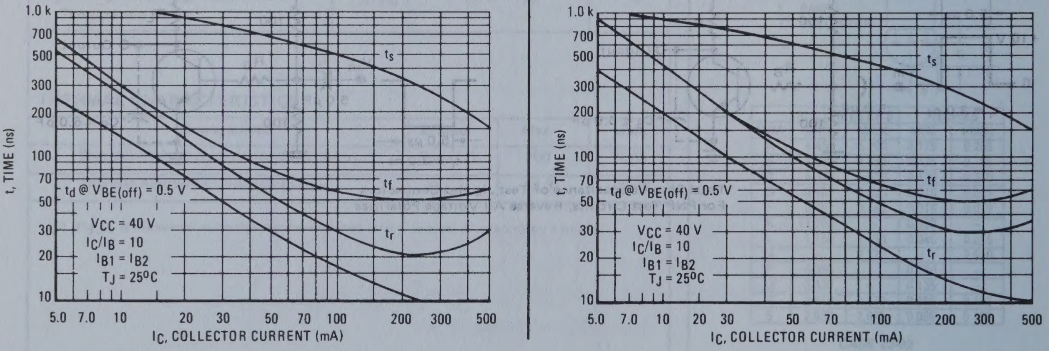


FIGURE 5 – THERMAL RESPONSE

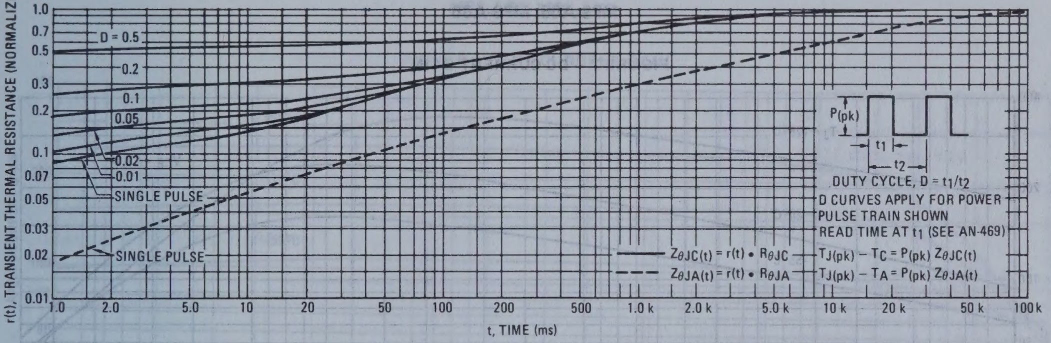
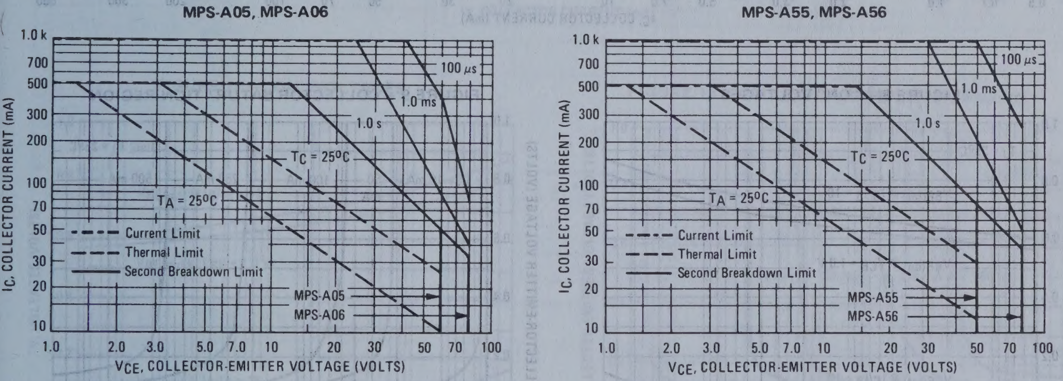


FIGURE 6 – ACTIVE – REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 6 is based upon $T_{J(pk)} = 150^{\circ}C$; T_C or T_A is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 5. At high case or ambient temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown. (See AN-415A)

NPN
MPS-A05, MPS-A06

FIGURE 7 – DC CURRENT GAIN

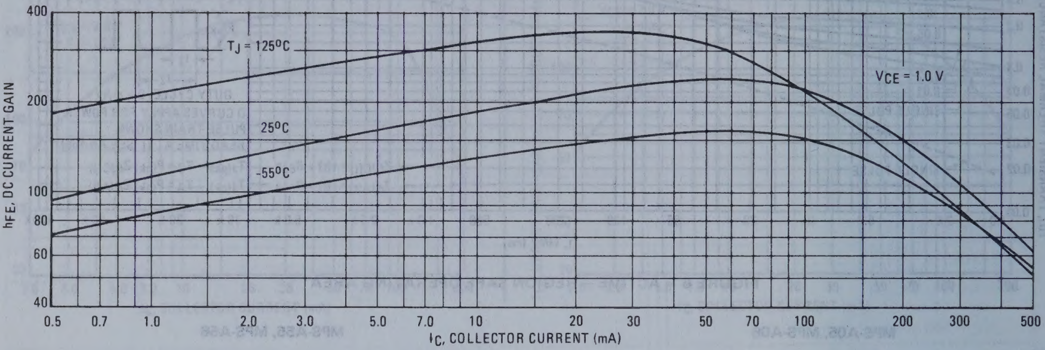


FIGURE 8 – "ON" VOLTAGES

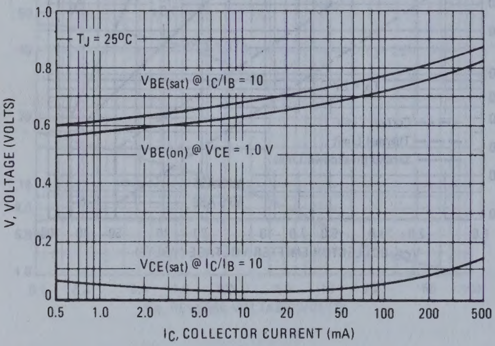


FIGURE 9 – COLLECTOR SATURATION REGION

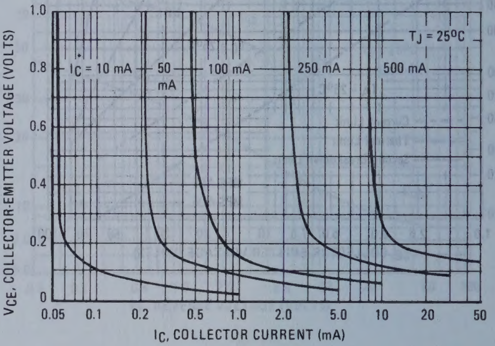
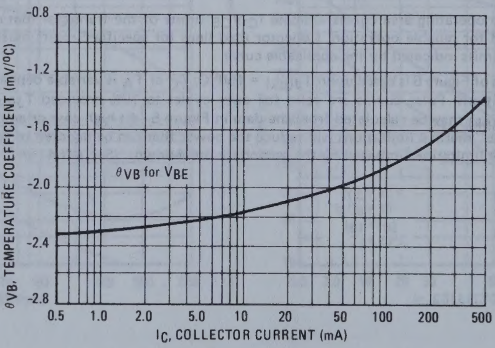


FIGURE 10 – BASE-EMITTER TEMPERATURE COEFFICIENT



PNP
MPS-A55, MPS-A56

FIGURE 11 – DC CURRENT GAIN

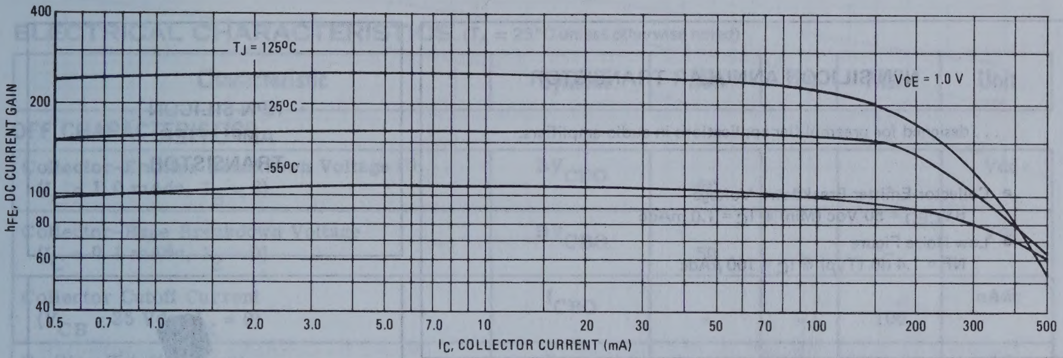


FIGURE 12 – "ON" VOLTAGES

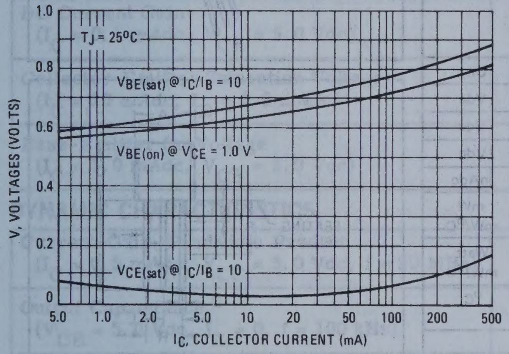


FIGURE 13 – COLLECTOR SATURATION REGION

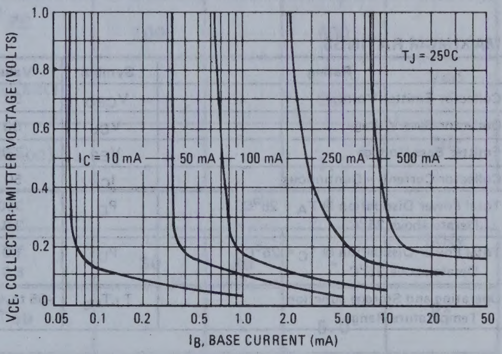
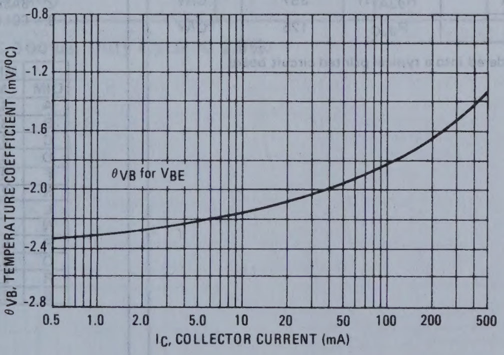


FIGURE 14 – BASE-EMITTER TEMPERATURE COEFFICIENT



MPS-A09 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for preamplifier applications in audio amplifiers.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 50 Vdc (Min) @ I_C = 1.0 mAdc
- Low Noise Figure — NF = 1.4 dB (Typ) @ I_C = 100 μAdc

NPN SILICON
AMPLIFIER
TRANSISTOR

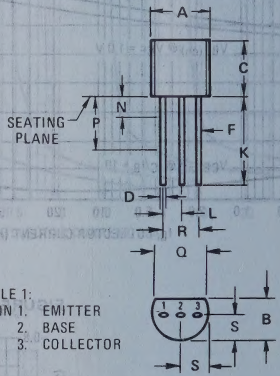
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	50	-	-	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	100	-	600	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.9	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.5 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	30	80	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	-	5.0	pF
Noise Figure (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc, R_S = 6.8 k ohms, f = 1.0 kHz)	NF	-	1.4	-	dB

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 1 – DC CURRENT GAIN

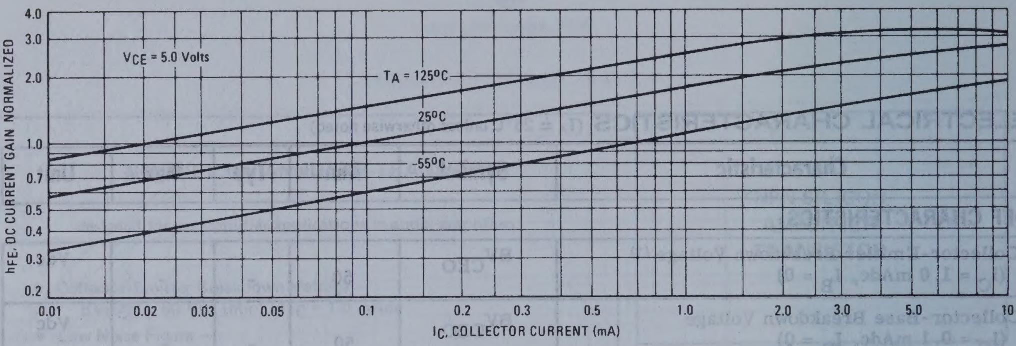


FIGURE 2 – COLLECTOR SATURATION REGION

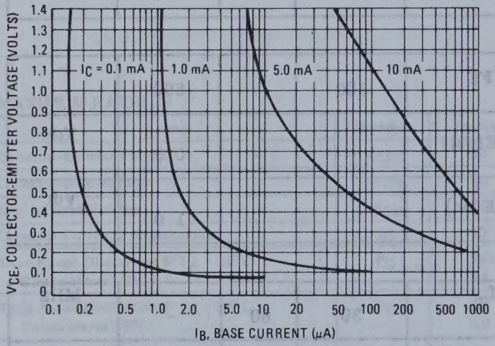
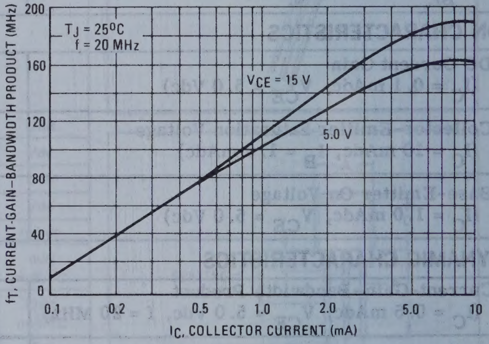


FIGURE 3 – CURRENT GAIN–BANDWIDTH PRODUCT



NOISE FIGURE

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 4 – FREQUENCY EFFECTS

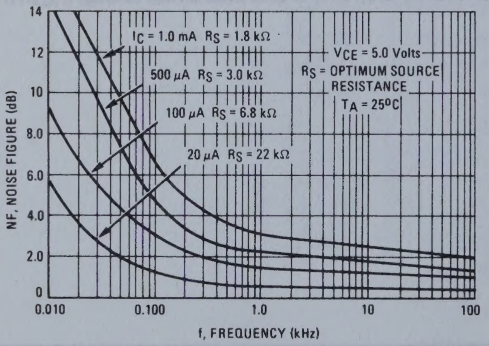
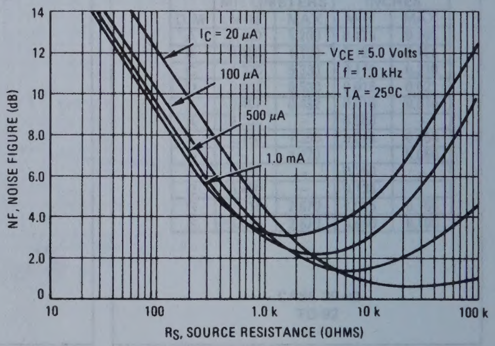


FIGURE 5 - SOURCE RESISTANCE EFFECT



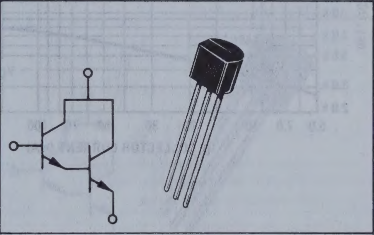
MPS-A12 (SILICON)
MPS-A14

NPN SILICON DARLINGTON TRANSISTOR

. . . designed for preamplifier input applications requiring input impedance of several megohms.

- Excellent Current-Gain Linearity from 1.0 mA to 100 mA
- Features Extremely High Current Gain – 20,000 (Min) @ I_C = 10 mAdc
- Monolithic Construction

NPN SILICON DARLINGTON TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

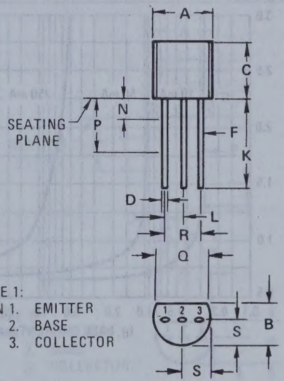
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	BV_{CES}	20	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	–	100	nAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20,000	–	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.01 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	–	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz	C_{ob}	–	8.0	–	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	–	35	–	–



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

FIGURE 1 – DC CURRENT GAIN

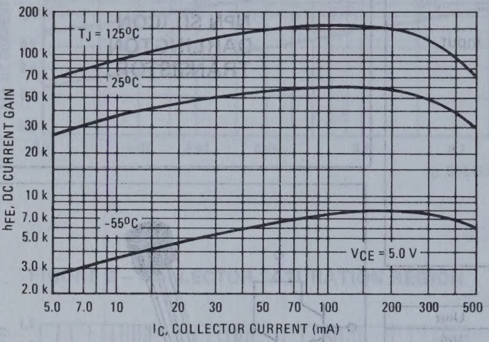


FIGURE 2 – "ON" VOLTAGES

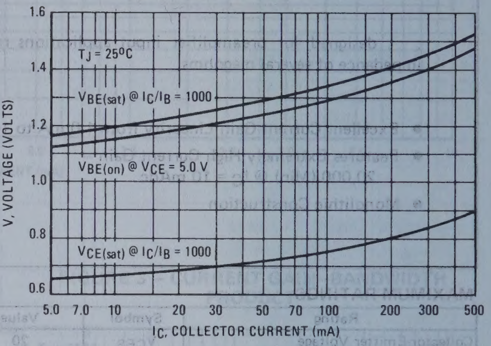


FIGURE 3 – COLLECTOR SATURATION REGION

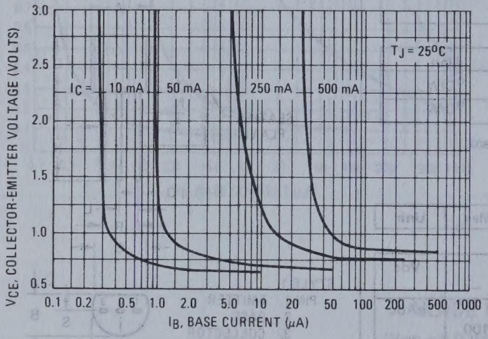


FIGURE 4 – TEMPERATURE COEFFICIENTS

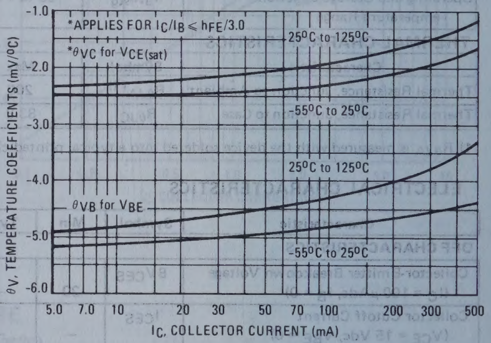


FIGURE 5 – HIGH FREQUENCY CURRENT GAIN

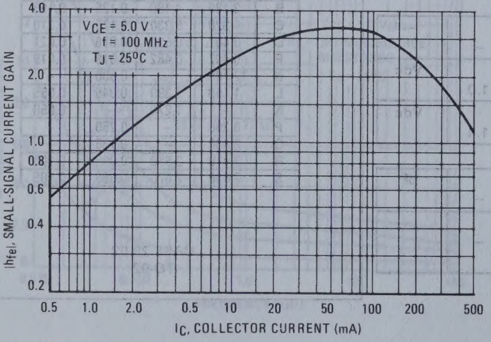
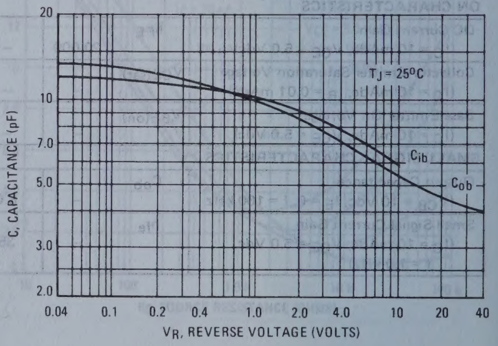


FIGURE 6 – CAPACITANCE



MPS-A13 (SILICON)
MPS-A14

NPN SILICON DARLINGTON AMPLIFIER TRANSISTORS

. . . designed for pre-amplifier input applications requiring high input impedance.

- High DC Current Gain @ I_C = 10 mAdc –
  h_{FE} = 5,000 (Min) MPS-A13
  10,000 (Min) MPS-A14
- Collector-Emitter Breakdown Voltage –
  BV_{CES} = 30 Vdc (Min) @ I_C = 100 μAdc
- Low Noise Figure –
  NF = 2.0 dB (Typ) @ I_C = 1.0 mAdc
- Monolithic Construction

MAXIMUM RATINGS

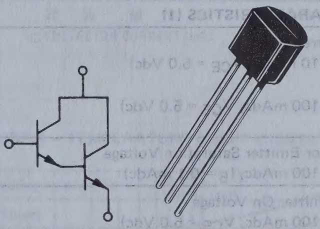
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

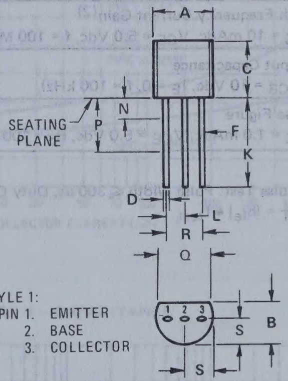
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON DARLINGTON TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	BV_{CES}	30	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) MPS-A13		5000	–	–	
MPS-A14		10,000	–	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc) MPS-A13		10,000	–	–	
MPS-A14		20,000	–	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	–	0.75	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	1.29	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
High Frequency Current Gain(2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	$\|h_{FE}\|$	1.25	2.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	5.4	–	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 k ohms, f = 1.0 kHz)	NF	–	2.0	–	dB

(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 1 – DC CURRENT GAIN

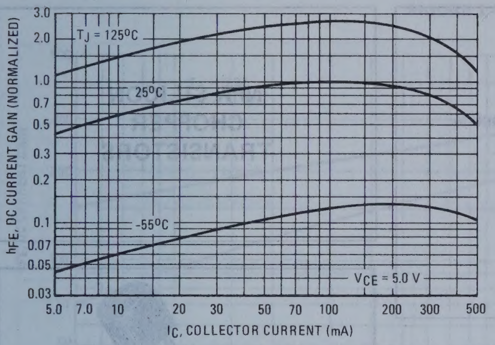


FIGURE 2 – "ON" VOLTAGES

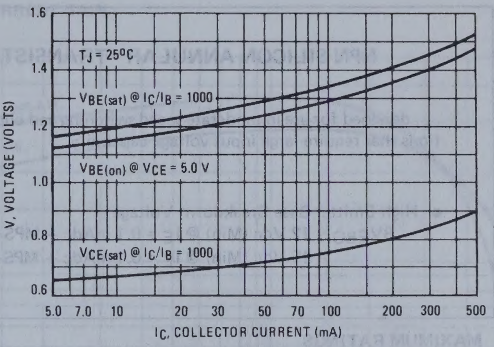


FIGURE 3 – COLLECTOR SATURATION REGION

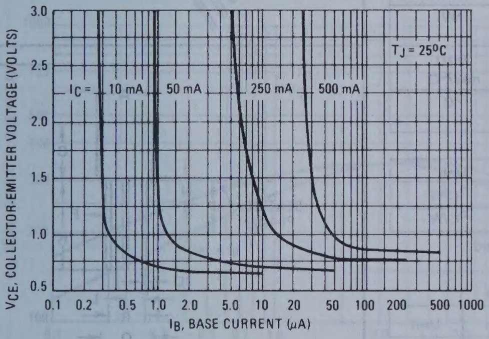


FIGURE 4 – TEMPERATURE COEFFICIENTS

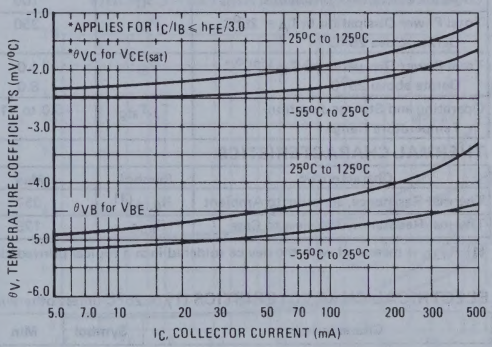


FIGURE 5 – HIGH FREQUENCY CURRENT GAIN

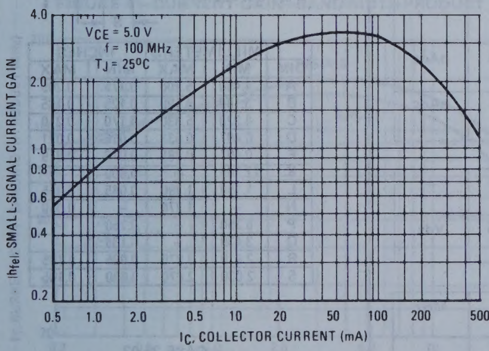
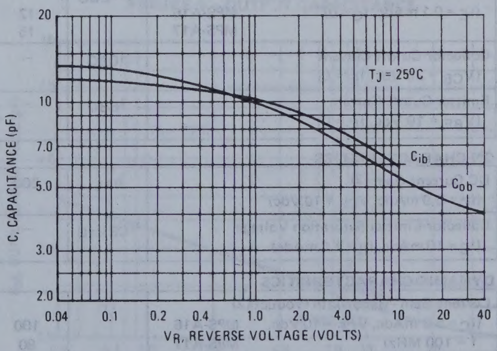


FIGURE 6 – CAPACITANCE



MPS-A16 (SILICON)
MPS-A17

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in moderate speed switching and clipping applications that require large input voltage capability.

- High-Emitter-Base Breakdown Voltage –
  BV_{EBO} = 12 Vdc (Min) @ I_E = 0.1 mAdc – MPS-A16
  = 15 Vdc (Min) @ I_E = 0.1 mAdc – MPS-A17

MAXIMUM RATINGS

Rating	Symbol	MPS-A16	MPS-A17	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EB}	12	15	Vdc
Collector Current – Continuous	I_C	100		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350		mW
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-5.0 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

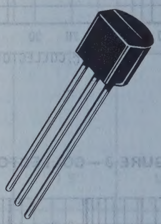
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

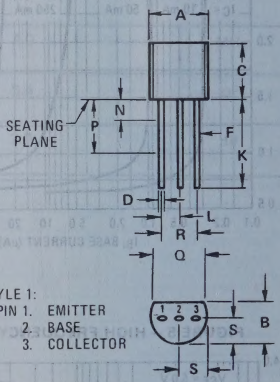
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0) MPS-A16 MPS-A17	BV_{EBO}	12 15	– –	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (2) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	200	600	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (2) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, MPS-A16 f = 100 MHz) MPS-A17	f_T	100 80	– –	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	4.0	pF

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

NPN SILICON CHOPPER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

FIGURE 1 – DC CURRENT GAIN

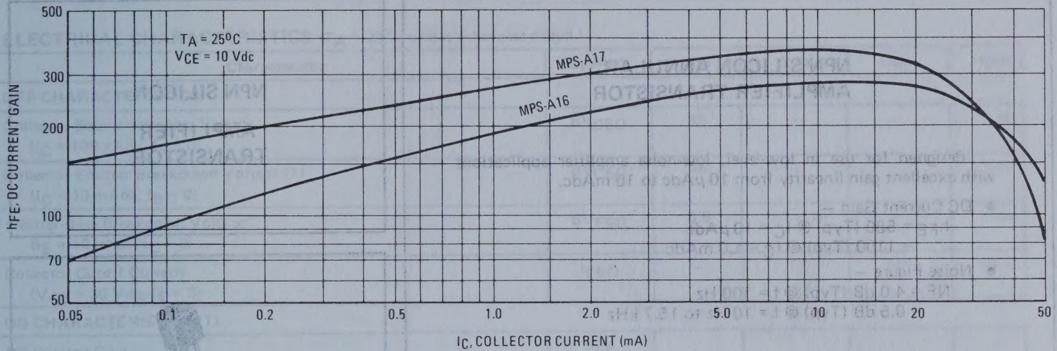


FIGURE 2 – SMALL SIGNAL CURRENT GAIN

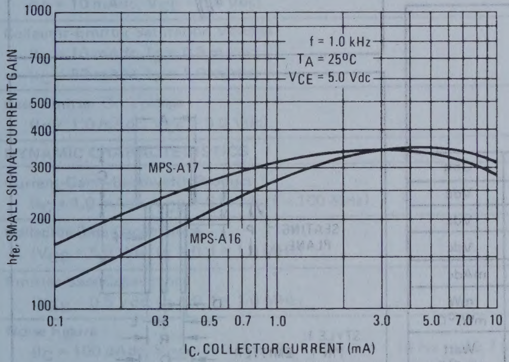


FIGURE 3 – SATURATION AND ON VOLTAGES

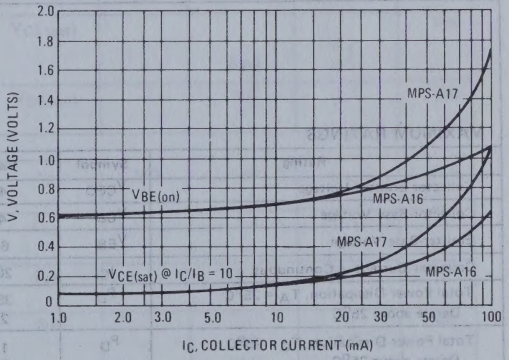


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

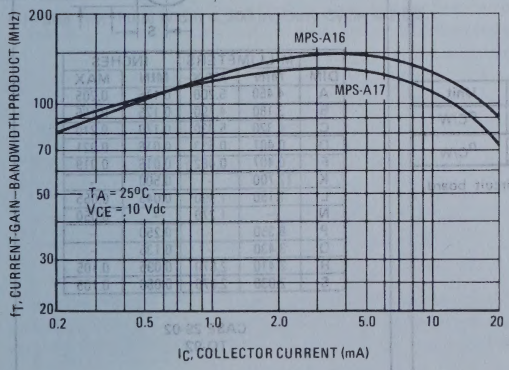
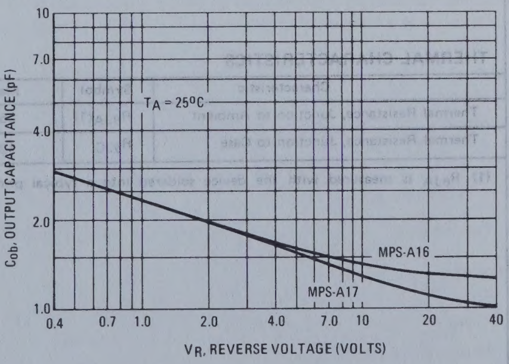


FIGURE 5 – OUTPUT CAPACITANCE



MPS-A18 (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use in low-level, low-noise amplifier applications with excellent gain linearity from 10 μAdc to 10 mAdc.

- DC Current Gain —
  h_{FE} = 580 (Typ) @ I_C = 10 μAdc
  = 1100 (Typ) @ I_C = 1.0 mAdc
- Noise Figure —
  NF = 4.0 dB (Typ) @ f = 100 Hz
  = 0.5 dB (Typ) @ f = 10 Hz to 15.7 kHz

MAXIMUM RATINGS

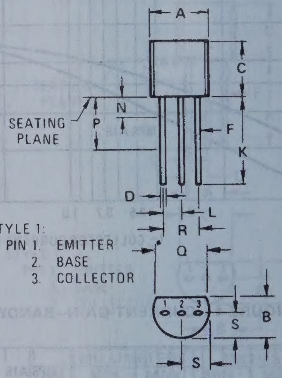
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	6.5	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation, T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation, T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON AMPLIFIER TRANSISTOR



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

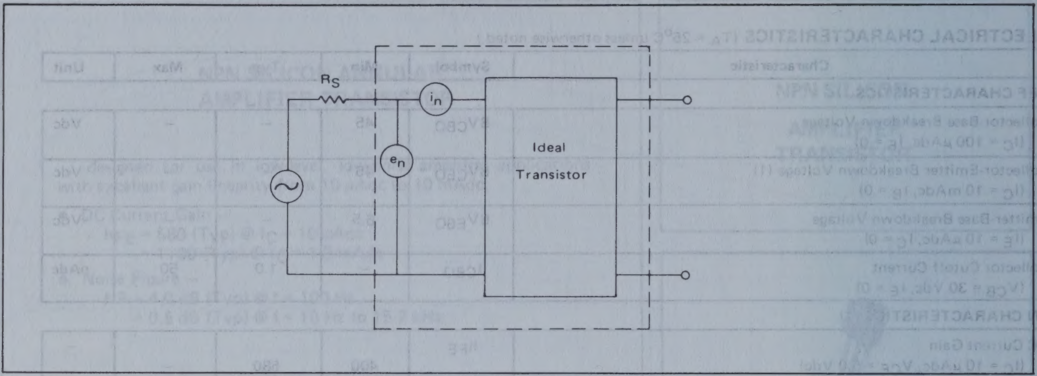
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	–	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	1.0	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 400 500 500 500	 580 850 1100 1150	 – – – 1500	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 – –	 – 0.08	 0.2 0.3	Vdc
Base Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.6	0.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	160	–	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	1.7	3.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	–	5.6	6.5	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ, f = 10 Hz to 15.7 kHz) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 100 Hz)	NF	 – –	 0.5 4.0	 1.5 –	dB
Equivalent Short Circuit Noise Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 kΩ, f = 100 Hz)	V_T	–	6.5	–	$nV/\sqrt{Hz}$

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

FIGURE 1 – TRANSISTOR NOISE MODEL



NOISE APPLICATION NOTE

For a transistor, total noise at the input may be expressed as:

$$V_T = \left[e_n^2 + 4KT\,R_S + i_n^2\,R_S^2 \right]^{1/2} \qquad (1)$$

(See Figure 1)

Where:

V_T = total noise voltage at the transistor input (Volts/$\sqrt{\text{Hz}}$)

e_n = noise voltage of the transistor referred to the input (Figures 2 and 3)

i_n = noise current of the transistor referred to the input (Figure 4)

K = Boltzman's constant (1.38 x 10^{-23} j/°K)

T = temperature of the source resistance (°K)

R_S = source resistance (Ohms)

Example:

Find the total noise at the input of an MPS-A18 for a collector current of 1.0 mA and a source impedance of 1.0 Kilohm at a frequency of 100 Hz and at a temperature of 25°C.

Read e_n = 4.6 nV/$\sqrt{\text{Hz}}$ from Figure 2 or Figure 3. (Note that this is for a one cycle bandwidth)

Read i_n = 3.6 pA/$\sqrt{\text{Hz}}$ from Figure 4.

$$V_T = \left[(4.6 \times 10^{-9})^2 + (4)(1.38 \times 10^{-23})(300)(1 \times 10^3) + (3.6 \times 10^{-12})^2\,(1 \times 10^3)^2\right]^{1/2} = 7.2\ \text{nV}/\sqrt{\text{Hz}}$$

This checks with the value shown in Figure 6.

Example:

Read V_T = 7.2 nV/$\sqrt{\text{Hz}}$ at I_C = 1.0 mA and R_S = 1.0 kΩ.

Noise figure is defined as:

$$\text{NF} = 20 \log_{10} \frac{\text{total noise voltage}}{\text{noise voltage contributed by the Source Resistance}}$$

or

$$\text{NF} = 20 \log_{10} \left(\frac{V_T^2}{4\,KT\,R_S} \right)^{1/2} \qquad (2)$$

Noise figure can be calculated for the above example as follows:

$$\text{NF} = 20 \log_{10} \left[\frac{(7.2 \times 10^{-9})^2}{16.6 \times 10^{-18}} \right]^{1/2} = 4.9\ \text{dB}$$

This checks with the value read from Figure 7 of 5.0 dB.

To minimize noise in a transistor stage, one might use Figure 7 and deduce that noise is minimized when Noise Figure is minimum. This is not necessarily true as shown by Figure 6 where the total noise voltage is a minimum at small values of source impedance. This can be seen from equation (1) which shows that total noise is a direct function of source resistance.

Noise over a frequency band can be handled in one of two ways depending upon whether total transistor noise is constant or variable over the bandwidth of interest:

1. For Constant transistor noise, multiply, V_T by the square root of bandwidth. i.e., $V'_T = V_T \bullet \Delta f^{1/2}$
2. For variable transistor noise, plot V_T (where Δf = 1.0 Hz) versus frequency over the bandwidth and integrate the result.

Total noise voltage at the output of the transistor stage can be found by multiplying V_T or V'_T by the voltage gain of the stage.

NOISE CHARACTERISTICS

(V_{CE} = 5.0 Vdc, T_A = 25°C)

NOISE VOLTAGE

FIGURE 2 – EFFECTS OF FREQUENCY

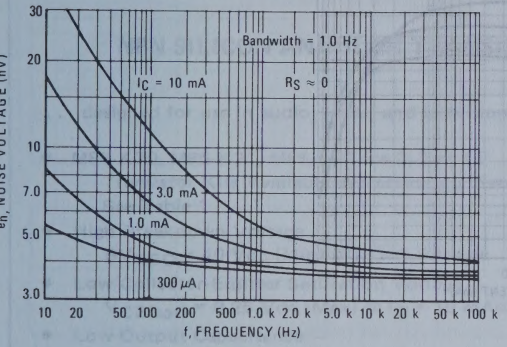


FIGURE 3 – EFFECTS OF COLLECTOR CURRENT

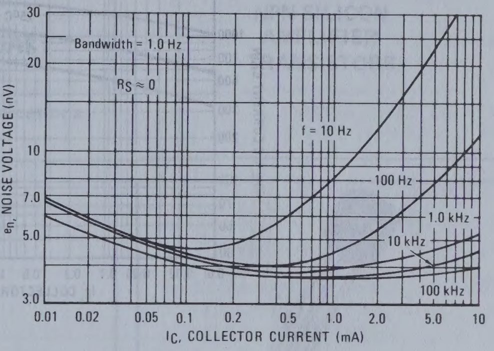


FIGURE 4 – NOISE CURRENT

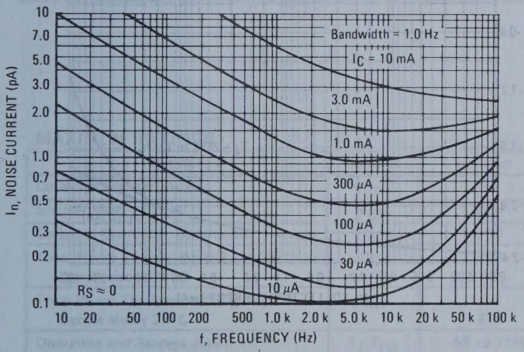
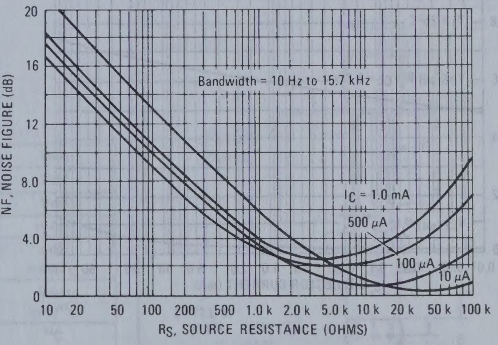


FIGURE 5 – WIDEBAND NOISE FIGURE



100 Hz NOISE DATA

FIGURE 6 – TOTAL NOISE VOLTAGE

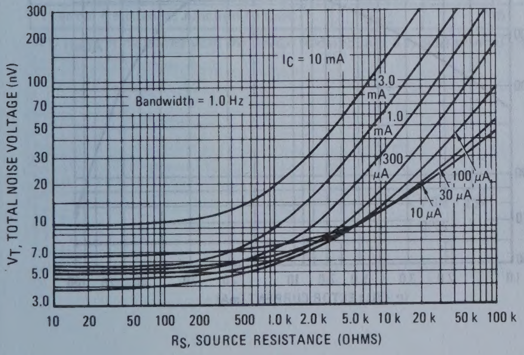


FIGURE 7 – NOISE FIGURE

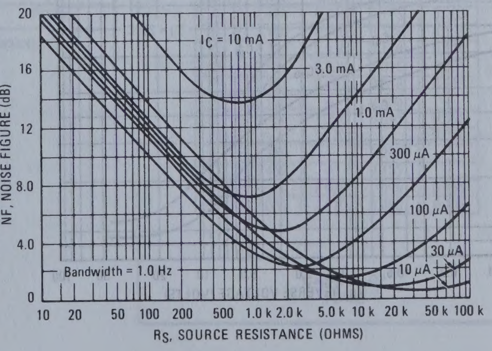


FIGURE 8 – DC CURRENT GAIN

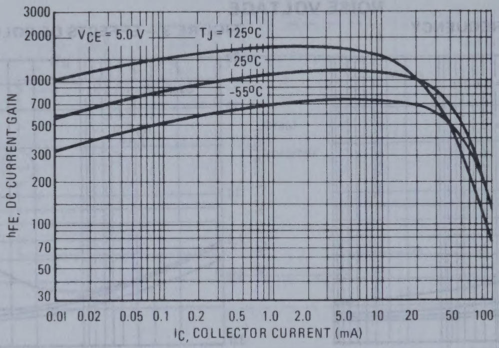


FIGURE 9 – "ON" VOLTAGES

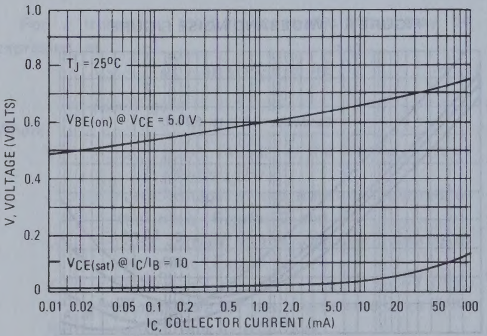


FIGURE 10 – TEMPERATURE COEFFICIENTS

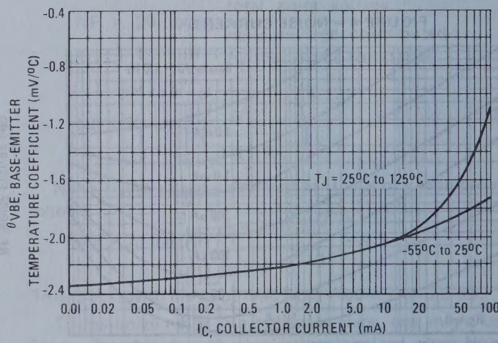


FIGURE 11 – CAPACITANCE

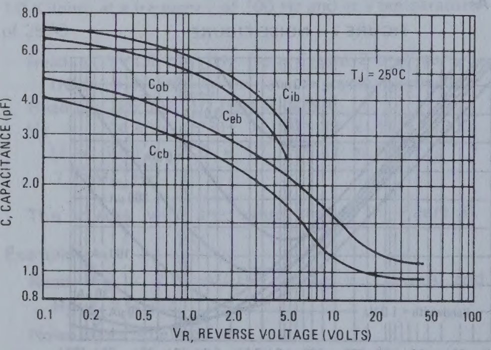
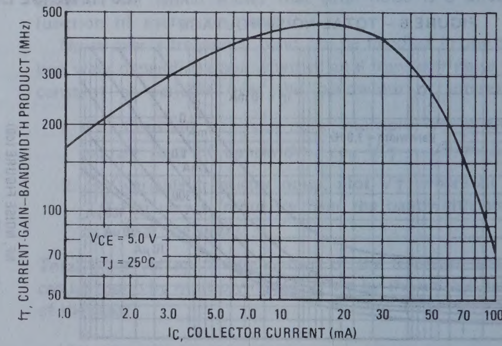


FIGURE 12 – CURRENT-GAIN–BANDWIDTH PRODUCT



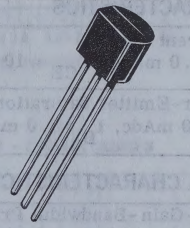
MPS-A20 (SILICON)
MPS-K20, MPS-K21,
MPS-K22

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in audio, radio, and television applications.

- MPS-K20, MPS-K21, MPS-K22 are 3, 5 and 9 Transistor Kits Available in Varied h_{FE} Ranges — See Table 1
- High Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 10 Vdc

NPN SILICON AMPLIFIER TRANSISTORS



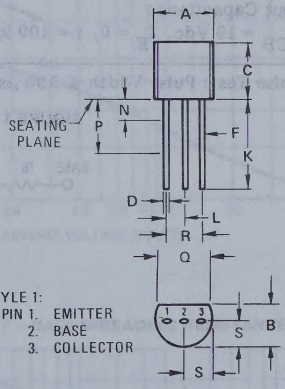
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

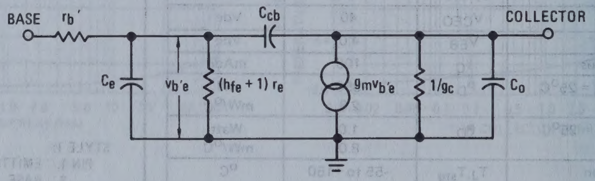
CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (2) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	40	400	-
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (2) ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	125	-	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	-	4.0	pF

(2) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-A20 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

r_b' – See Figure 8

$C_{cb} = C_{ob} - 0.2$ pF (See Figure 6)

$r_e = 26\ \text{mV}/I_E$

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\ h_{ob}$ (See Figures 2 & 7)

$C_e = \dfrac{1}{2\pi\ f_t\ r_e}$

$C_o = 0.2$ pF

Low frequency h parameters may be found from:

$h_{ie} = r_b' + (h_{fe} + 1)\ r_e$

h_{fe} = See Figure 2

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\ h_{ob}$

FIGURE 2 – SMALL SIGNAL CURRENT GAIN

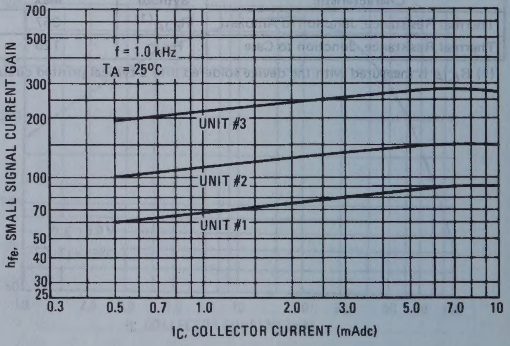


FIGURE 3 – NORMALIZED DC CURRENT GAIN

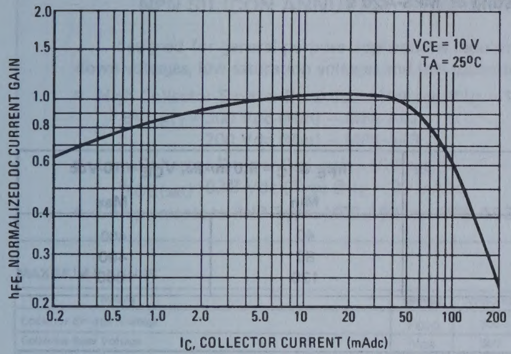


FIGURE 4 – "SATURATION" AND "ON" VOLTAGES

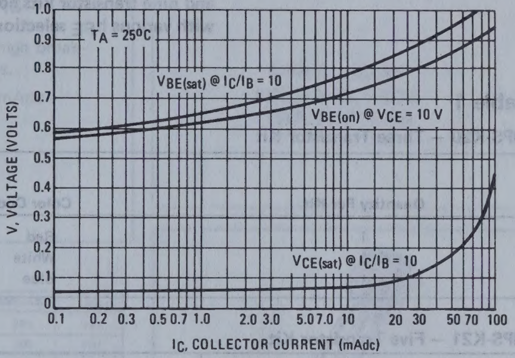


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

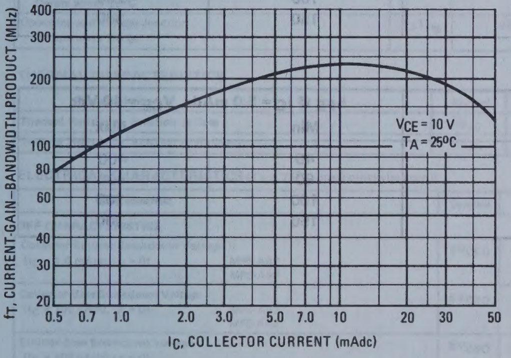


FIGURE 6 – CAPACITANCES

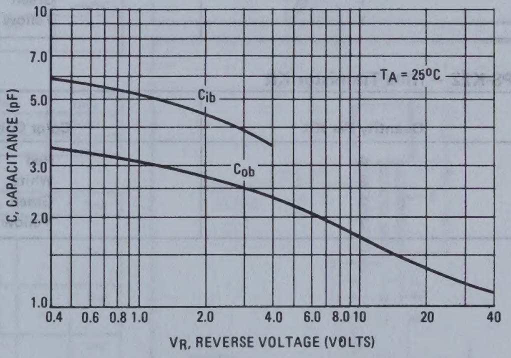


FIGURE 7 – OUTPUT ADMITTANCE

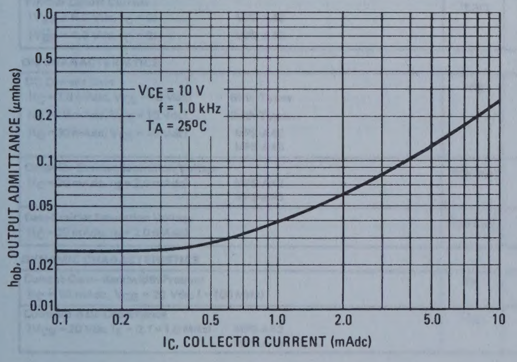
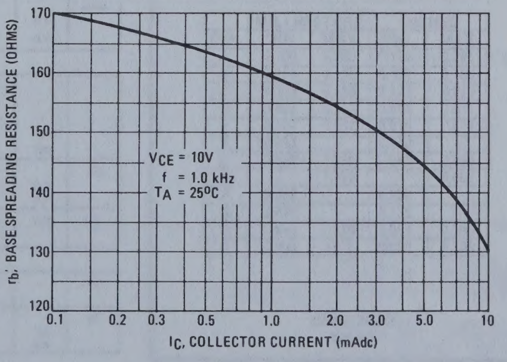


FIGURE 8 – BASE SPREADING RESISTANCE



MPS-K20, MPS-K21 and MPS-K22 are three, five and nine transistor kits consisting of MPS-A20's with various h_{FE} selections.

Table 1

MPS-K20 – Three Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
1	Red	40	400
1	White	80	400
1	Blue	120	300

MPS-K21 – Five Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
3	Red	40	400
1	Green	100	200
1	Yellow	150	300

MPS-K22 – Nine Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
4	Red	40	400
2	White	80	400
2	Green	100	200
1	Yellow	150	300

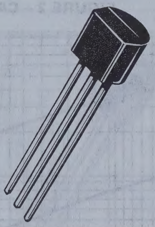
MPS-A42 (SILICON)
MPS-A43

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose applications requiring high breakdown voltages, low saturation voltages and low capacitance.

- High Collector-Emitter Breakdown Voltage @ I_C = 1.0 mAdc –
  BV_{CEO} = 300 Vdc (Min) – MPS-A42
  200 Vdc (Min) – MPS-A43
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.18 Vdc (Typ) @ I_C = 20 mAdc
- Complements to PNP Types MPS-A92 and MPS-A93

NPN SILICON
HIGH VOLTAGE
TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MPS-A42	MPS-A43	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CB}	300	200	Vdc
Emitter-Base Voltage	V_{EB}	6.0	6.0	Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

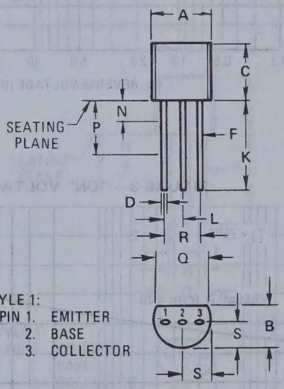
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0)	MPS-A42 MPS-A43	BV_{CEO}	300 200	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS-A42 MPS-A43	BV_{CBO}	300 200	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	6.0	– –	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 160 Vdc, I_E = 0)	MPS-A42 MPS-A43	I_{CBO}	– –	0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0) (V_{BE} = 4.0 Vdc, I_C = 0)	MPS-A42 MPS-A43	I_{EBO}	– –	0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	Both Types Both Types MPS-A42 MPS-A43	h_{FE}	25 40 40 50	– – – 200	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	MPS-A42 MPS-A43	$V_{CE(sat)}$	– –	0.5 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)		$V_{BE(sat)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	50	–	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	MPS-A42 MPS-A43	C_{cb}	– –	3.0 4.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

FIGURE 1 – DC CURRENT GAIN

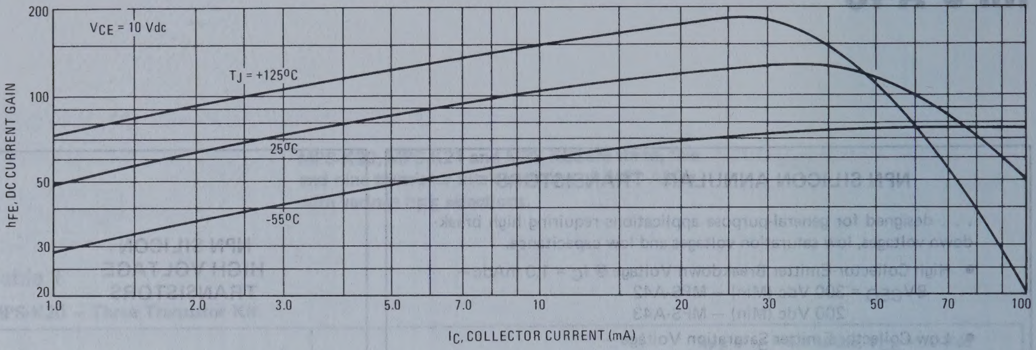


FIGURE 2 – CAPACITANCES

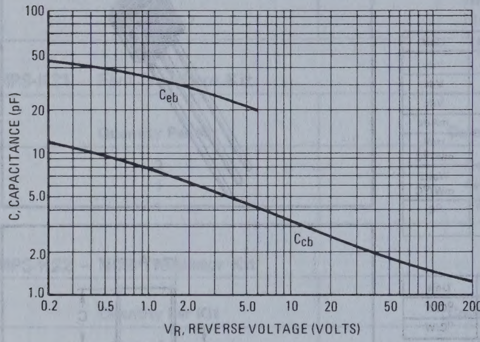


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

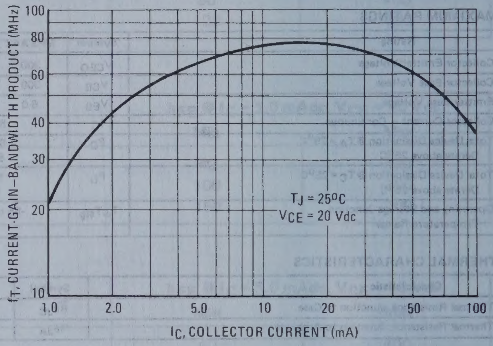


FIGURE 3 – "ON" VOLTAGES

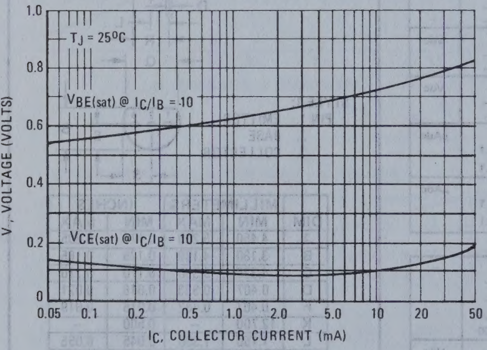
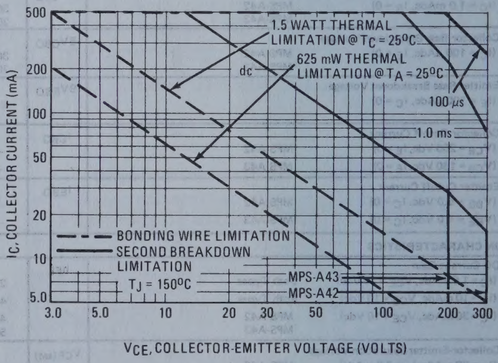


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



MPS-A55 (SILICON)
MPS-A56

For Specifications See MPS-A05 Data.

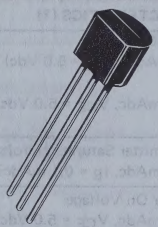
MPS-A65 (SILICON)
MPS-A66

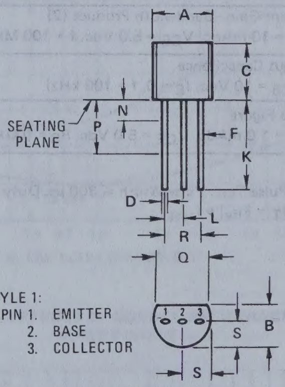
PNP SILICON DARLINGTON AMPLIFIER TRANSISTORS

. . . designed for pre-amplifier input applications requiring high input impedance.

- High DC Current Gain —
  h_{FE} = 50,000 (Min) @ I_C = 10 mAdc (MPS-A65)
  75,000 (Min) @ I_C = 10 mAdc (MPS-A66)
- Collector-Emitter Breakdown Voltage —
  BV_{CES} = 30 Vdc (Min) @ I_C = 100 μAdc
- Low Noise Figure —
  NF = 2.0 dB (Typ) @ I_C = 1.0 mAdc

PNP SILICON DARLINGTON TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)		BV_{CES}	30	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 8.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS-A65 MPS-A66	h_{FE}	50,000 75,000	– –	– –	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPS-A65 MPS-A66		20,000 40,000	– –	– –	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.9	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	1.45	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	175	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.5	–	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 k ohms, f = 1.0 kHz)		NF	–	2.0	–	dB

(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 1 — DC CURRENT GAIN

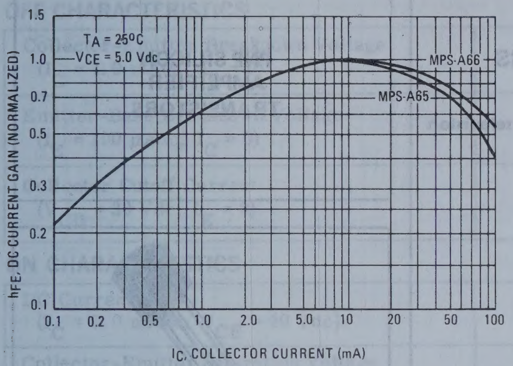


FIGURE 2 — BASE-EMITTER "ON" VOLTAGE

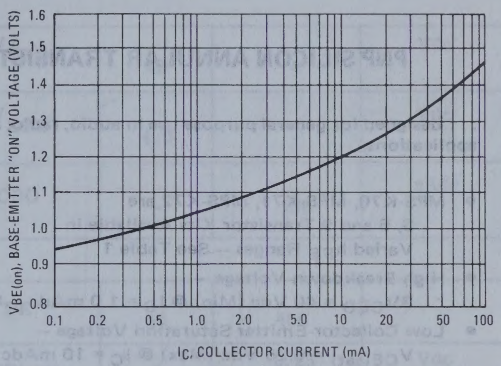


FIGURE 3 — EFFECTS OF FREQUENCY ON TRANSCONDUCTANCE

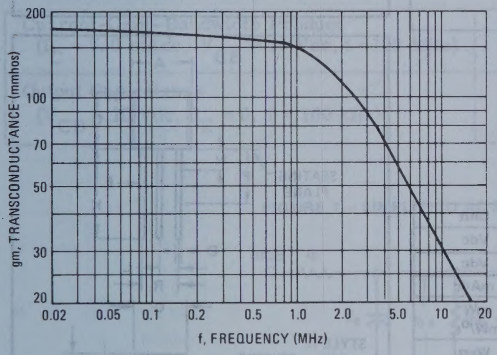


FIGURE 4 — EFFECTS OF COLLECTOR CURRENT ON NOISE FIGURE

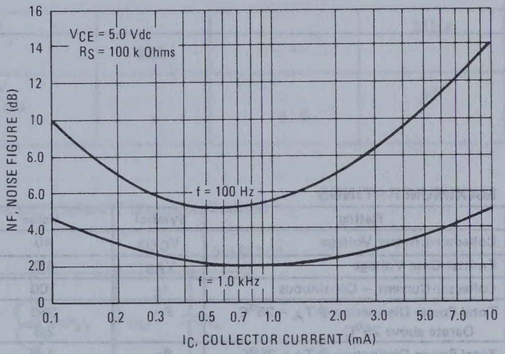


FIGURE 5 — EFFECTS OF FREQUENCY ON NOISE FIGURE

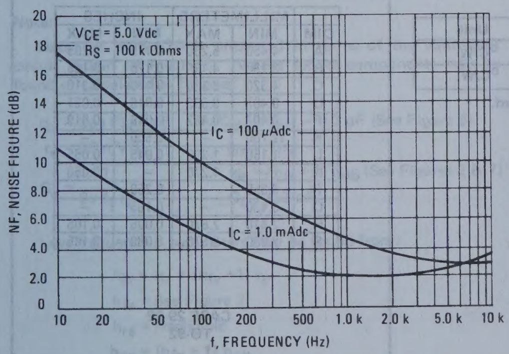
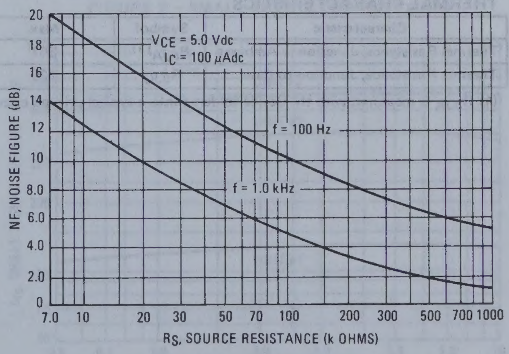


FIGURE 6 — EFFECTS OF SOURCE RESISTANCE ON NOISE FIGURE



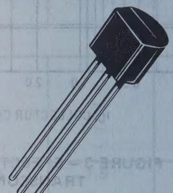
MPS-A70 (SILICON)
MPS-K70, MPS-K71
MPS-K72

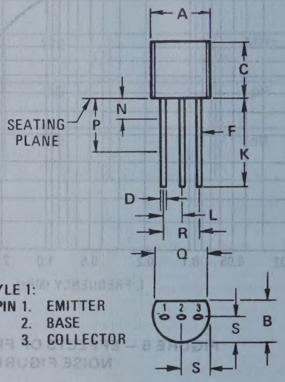
PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose use in audio, radio, and television applications.

- MPS-K70, MPS-K71, MPS-K72 are 3, 5 and 9 Transistor Kits Available in Varied h_{FE} Ranges – See Table 1
- High Breakdown Voltage – BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Low Output Capacitance – C_{ob} = 4.0 pF (Max) @ V_{CB} = 10 Vdc

PNP SILICON AMPLIFIER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

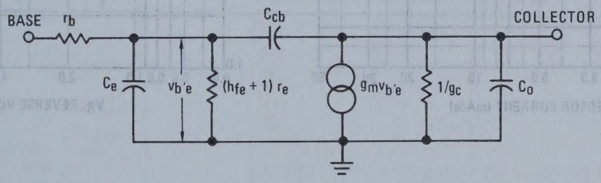
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-A70 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

r_b' – See Figure 8
$r_e = 26\ \text{mV}/I_E$
$C_e = \dfrac{1}{2\pi f_t r_e}$
$C_{cb} = C_{ob} - 0.2$ pF (See Figure 6)
$g_m = 1/r_e$
$g_c = (h_{fe}+1)\ h_{ob}$ (See Figures 2 & 7)
$C_o = 0.2$ pF

Low frequency h parameters may be found from:

$h_{ie} = r_b' + (h_{fe}+1)\ r_e$
h_{fe} = See Figure 2
h_{re} = Negligible
$h_{oe} = (h_{fe}+1)\ h_{ob}$

FIGURE 2 – SMALL SIGNAL CURRENT GAIN

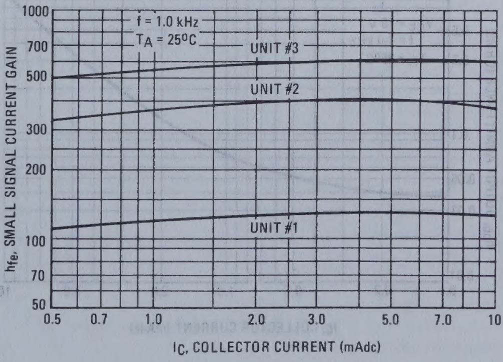


FIGURE 3 – NORMALIZED DC CURRENT GAIN

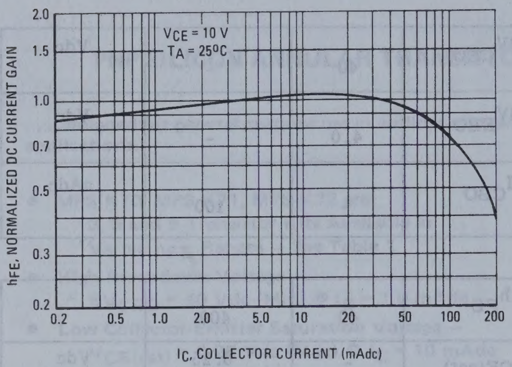


FIGURE 4 – "SATURATION" AND "ON" VOLTAGES

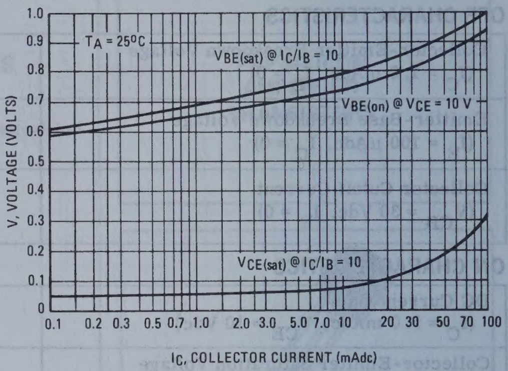


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

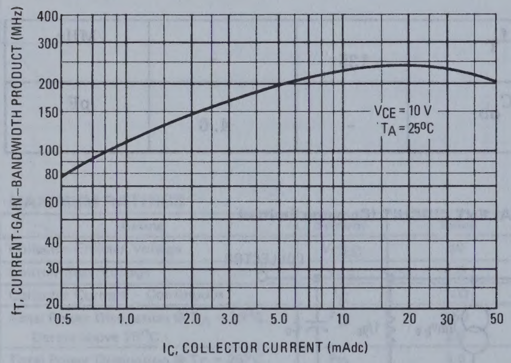


FIGURE 6 – CAPACITANCES

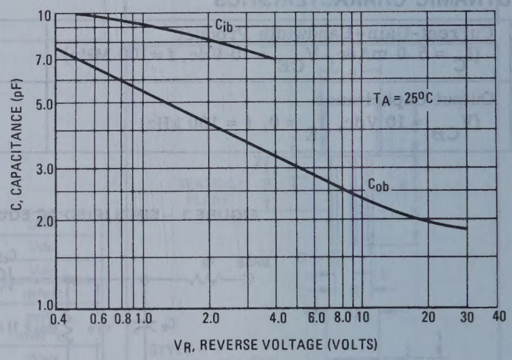


FIGURE 7 – OUTPUT ADMITTANCE

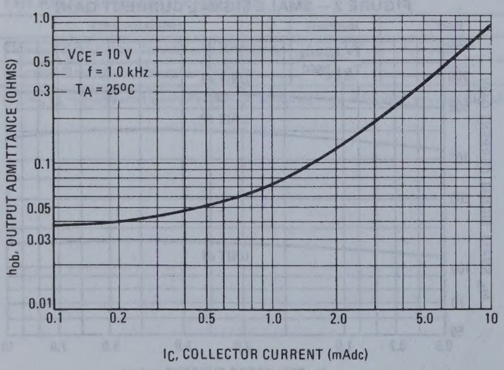
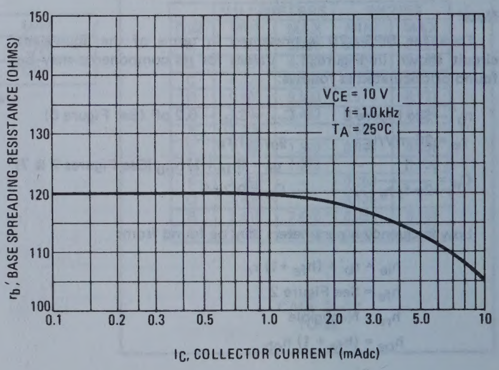


FIGURE 8 – BASE SPREADING RESISTANCE



MPS-K70, MPS-K71and MPS-K72 are three, five and nine transistor kits consisting of MPS-A70's with various h_{FE} selections.

Table 1

MPS-K70 – Three Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
1	Red	40	400
1	White	80	400
1	Blue	120	300

MPS-K71 – Five Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
3	Red	40	400
1	Green	100	200
1	Yellow	150	300

MPS-K72 – Nine Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
4	Red	40	400
2	White	80	400
2	Green	100	200
1	Yellow	150	300

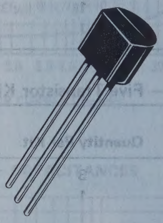
MPS-A92 (SILICON)
MPS-A93

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose applications requiring high breakdown voltages, low saturation voltages and low capacitance.

- High Collector-Emitter Breakdown Voltage @ I_C = 1.0 mAdc –
  BV_{CEO} = 300 Vdc (Min) – MPS-A92
  200 Vdc (Min) – MPS-A93
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.12Vdc (Typ) @ I_C = 20 mAdc
- Complements to NPN Types MPS-A42 and MPS-A43

PNP SILICON
HIGH VOLTAGE
TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MPS-A92	MPS-A93	Unit
Collector-Emitter Voltage	V_{CEO}	300	200	Vdc
Collector-Base Voltage	V_{CB}	300	200	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

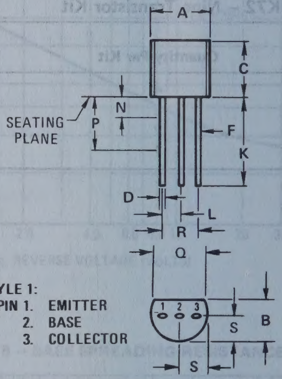
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Emitter Breakdown Voltage(1) (I_C = 1.0 mAdc, I_B = 0) MPS-A92 MPS-A93	BV_{CEO}	300 200	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) MPS-A92 MPS-A93	BV_{CBO}	300 200	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) MPS-A92 (V_{CB} = 160 Vdc, I_E = 0) MPS-A93	I_{CBO}	– –	0.25 0.25	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) Both Types (I_C = 10 mAdc, V_{CE} = 10 Vdc) Both Types (I_C = 30 mAdc, V_{CE} = 10 Vdc) MPS-A92 MPS-A93	h_{FE}	25 40 25 30	– – – 150	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc) MPS-A92 MPS-A93	$V_{CE(sat)}$	– –	0.5 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	–	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz) MPS-A92 MPS-A93	C_{cb}	– –	6.0 8.0	pF

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

FIGURE 1 – DC CURRENT GAIN

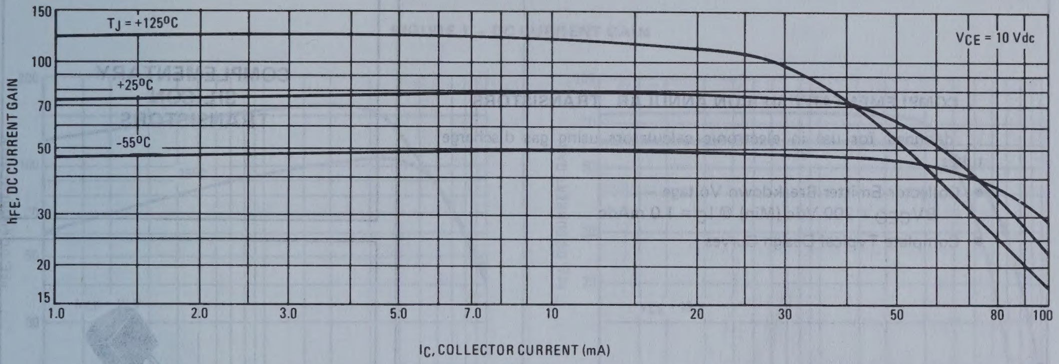


FIGURE 2 – CAPACITANCES

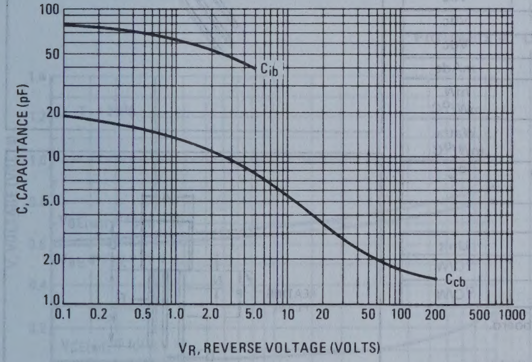


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

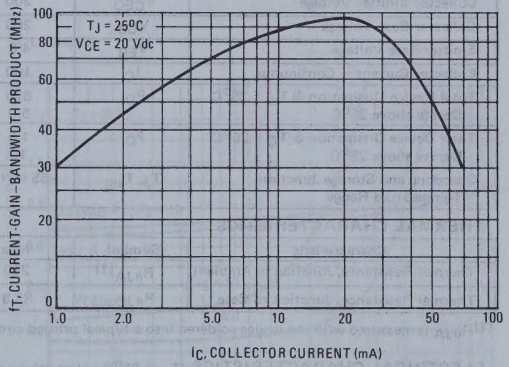


FIGURE 4 – "ON" VOLTAGES

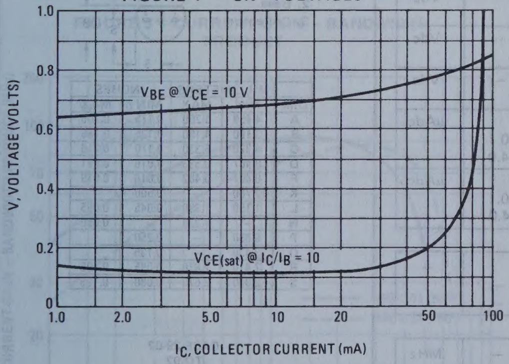
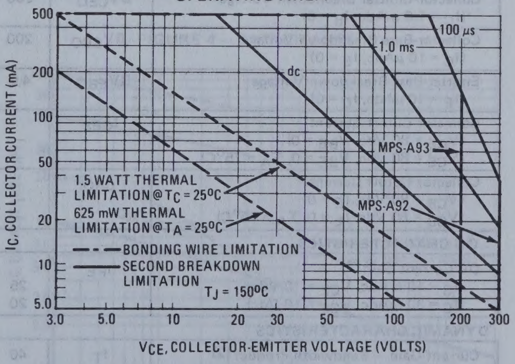


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



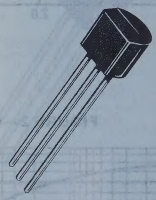
MPS-D01 NPN (SILICON)
MPS-D51 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in electronic calculators using gas discharge tubes.

- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 200 Vdc (Min) @ I_C = 1.0 mAdc
- Complete Typical Design Curves

COMPLEMENTARY
SILICON
TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	200	Vdc
Collector-Base Voltage	V_{CB}	200	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

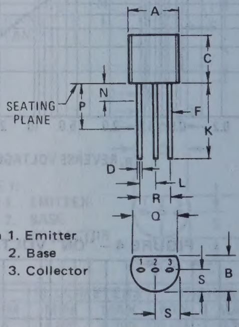
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	200	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	200	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0) (V_{CE} = 80 Vdc, V_{BE} = 0, T_A = 75°C)	I_{CES}	 – –	 0.1 4.0	μAdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0, T_A = 75°C)	I_{CBO}	 – –	 0.1 4.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (2) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 20	 – –	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	40	–	MHz

(2) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.



Pin 1. Emitter
2. Base
3. Collector

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

NPN
MPS-D01

PNP
MPS-D51

FIGURE 1 – DC CURRENT GAIN

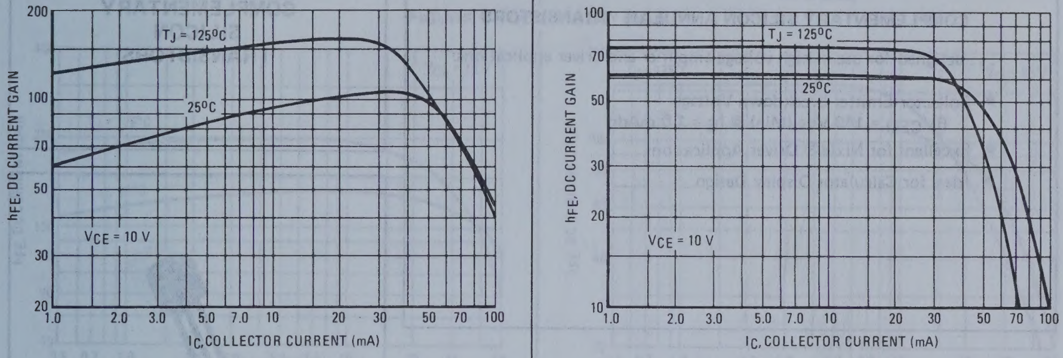


FIGURE 2 – "ON" VOLTAGES

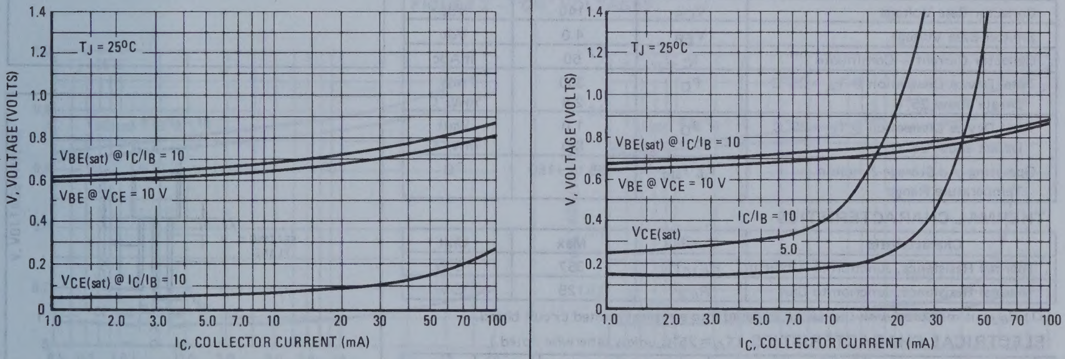


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

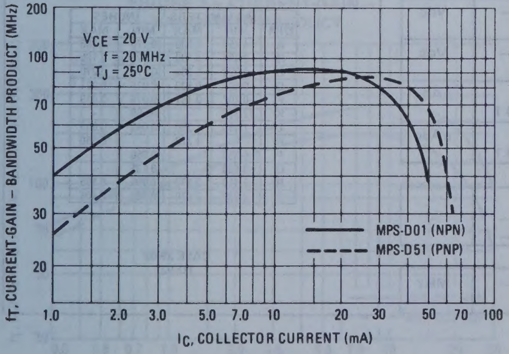
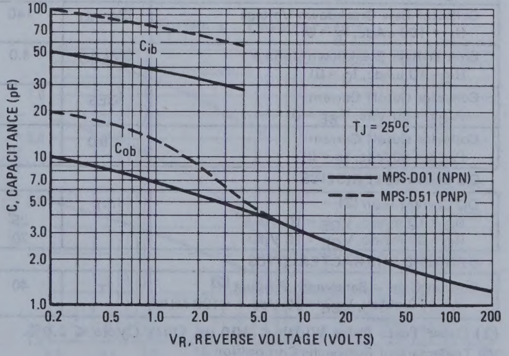


FIGURE 4 – CAPACITANCE



MPS-D02 NPN (SILICON)
MPS-D52 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in high voltage amplifier and driver applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 140 Vdc (Min) @ I_C = 1.0 mAdc
- Excellent for Nixie® Driver Applications
- Ideal for Calculator Display Design

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	140	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	140	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CES}	–	0.1	μAdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (2) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 20	 – –	–
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	40	–	MHz

(2) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

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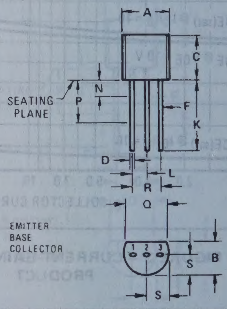
COMPLEMENTARY SILICON TRANSISTORS



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

NPN
MPS-D02

PNP
MPS-D52

FIGURE 1 – DC CURRENT GAIN

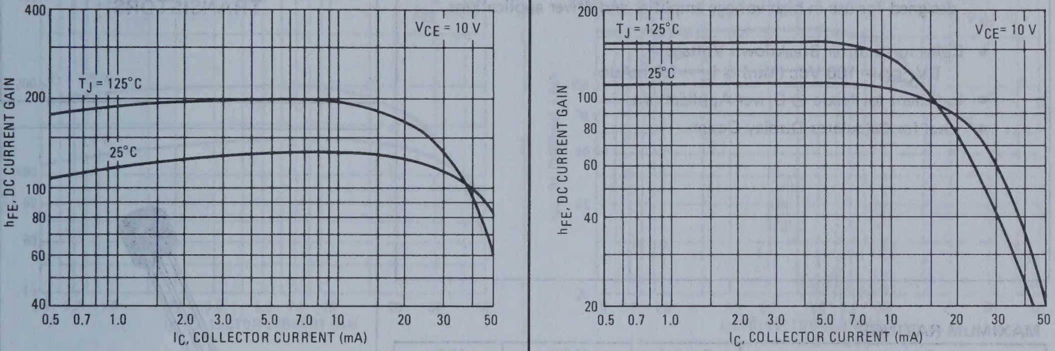


FIGURE 2 – "ON" VOLTAGES

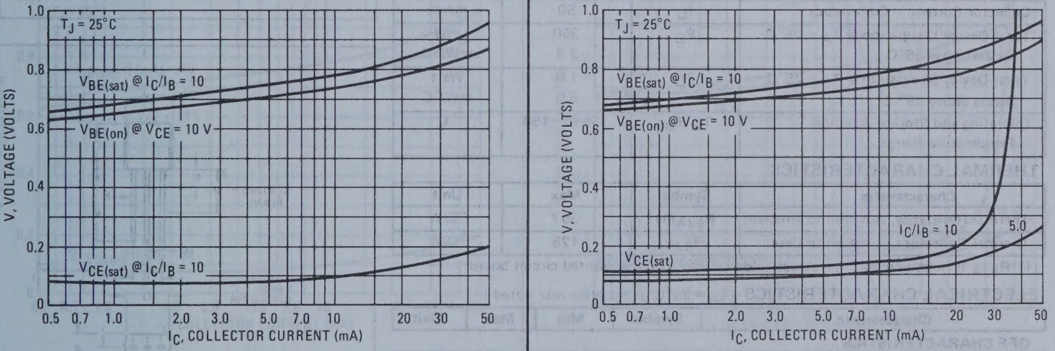


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

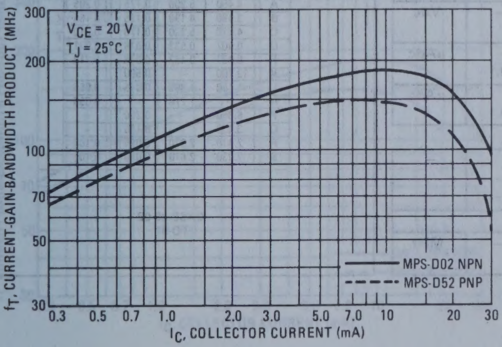
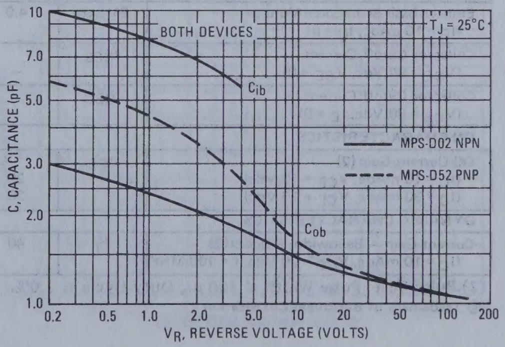


FIGURE 4 – CAPACITANCE



MPS-D03 NPN (SILICON)
MPS-D53 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in high voltage amplifier and driver applications.

- Collector-Emitter Breakdown Voltage – BV_{CEO} = 100 Vdc (Min) @ I_C = 1.0 mAdc
- Excellent for Nixie ® Driver Applications
- Ideal for Calculator Display Design

COMPLEMENTARY SILICON TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

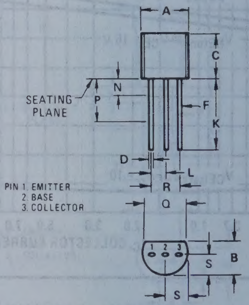
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CES}	–	0.1	μAdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (2) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 20	 – –	–
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	40	–	MHz

(2) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

® Trademark of Burroughs Corporation



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

NPN
MPS-D03

PNP
MPS-D53

FIGURE 1 – DC CURRENT GAIN

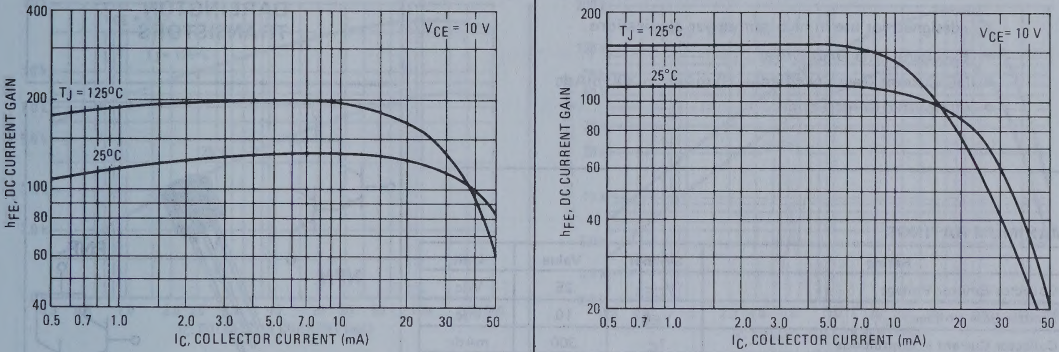


FIGURE 2 – "ON" VOLTAGES

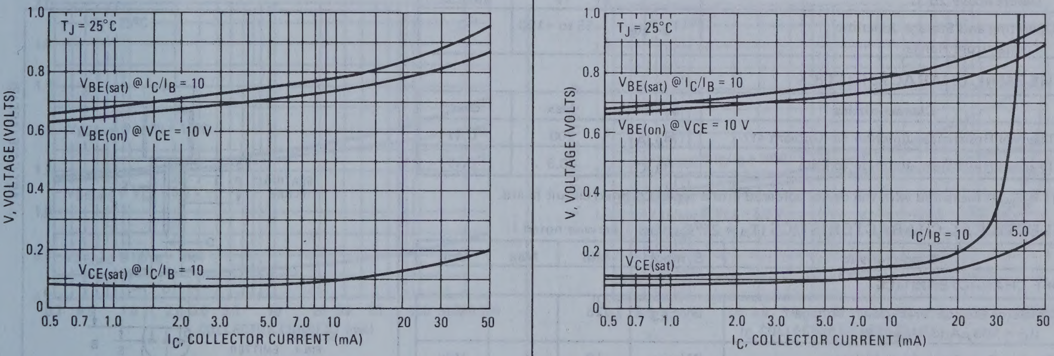


FIGURE 3 – CURRENT-GAIN – BANDWIDTH PRODUCT

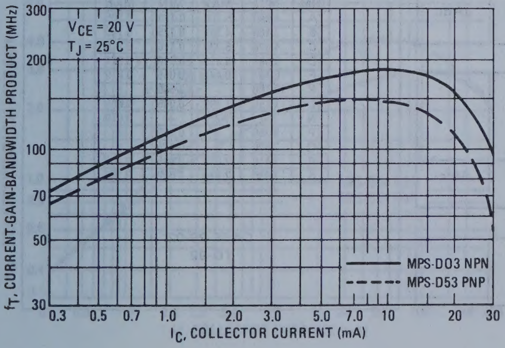
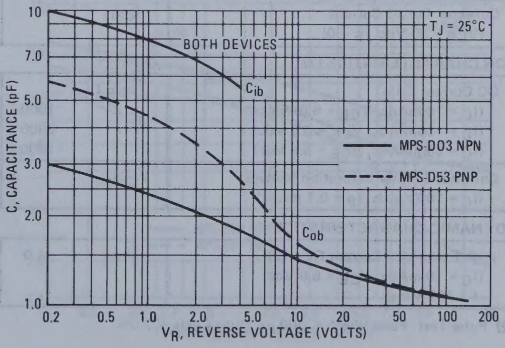


FIGURE 4 – CAPACITANCE



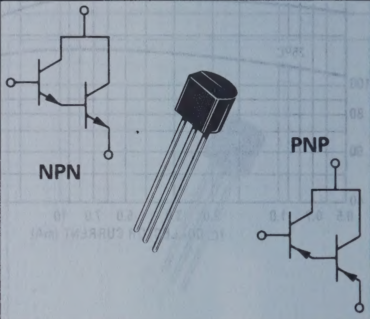
MPS-D04 NPN (SILICON)
MPS-D54 PNP

COMPLEMENTARY DARLINGTON SILICON ANNULAR TRANSISTORS

. . . designed for use in high gain driver applications.

- Excellent LED Digit Driver
- DC Current Gain Specified — 10 mAdc to 300 mAdc
- Monolithic Construction

COMPLEMENTARY SILICON DARLINGTON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

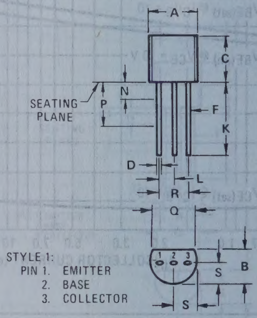
Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	200	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu Adc$, $V_{BE} = 0$)	BV_{CES}	25	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu Adc$, $I_C = 0$)	BV_{EBO}	10	–	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)	I_{CES}	–	1.0	µAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	–	1.0	µAdc
ON CHARACTERISTICS (2)				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 300$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 1000 2000 1000	 – – –	–
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 0.1$ mAdc)	$V_{CE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
High Frequency Current Gain (2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	$\lvert h_{fe}\rvert$	1.0	–	

(2) Pulse Test: Pulse Width $\leqslant 300\ \mu s$, Duty Cycle $\leqslant 2.0\%$.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

TYPICAL CHARACTERISTICS

NPN
MPS-D04

PNP
MPS-D54

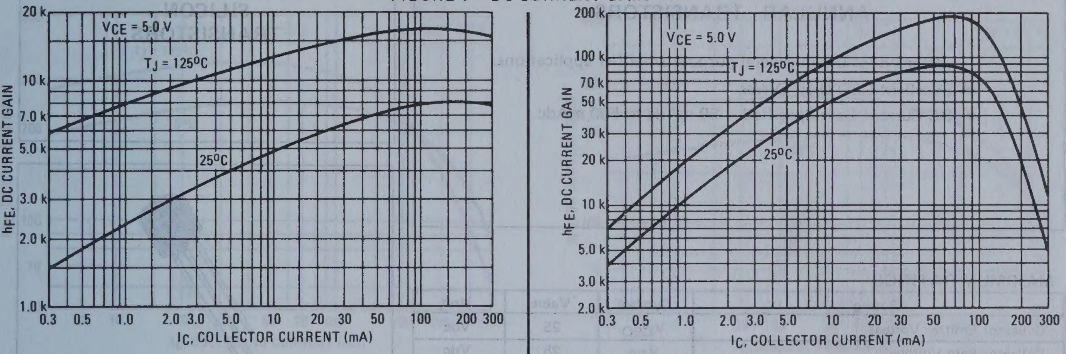


FIGURE 1 – DC CURRENT GAIN

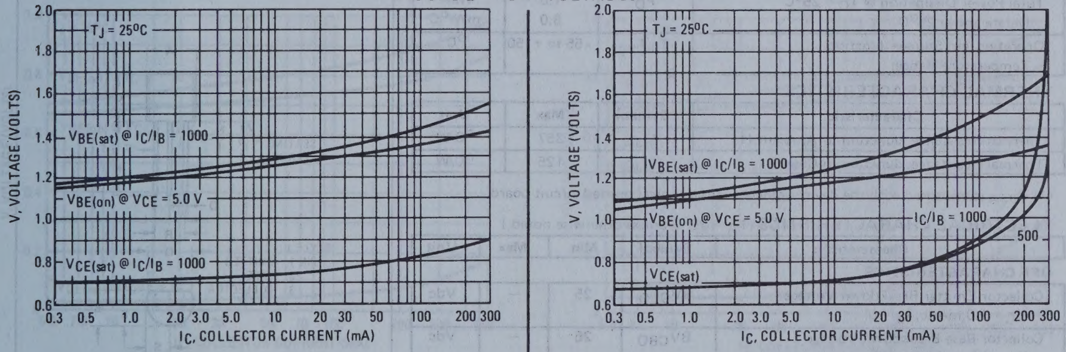


FIGURE 2 – "ON" VOLTAGES

FIGURE 3 – HIGH FREQUENCY CURRENT GAIN

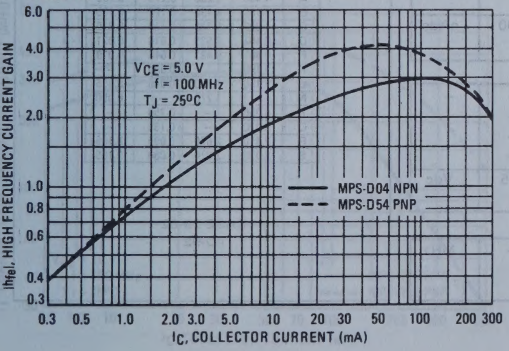
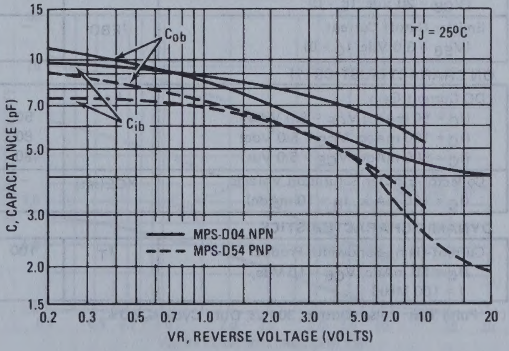


FIGURE 4 – CAPACITANCE



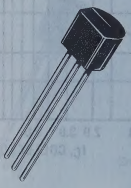
MPS-D05 NPN (SILICON)
MPS-D55 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in general purpose amplifier applications.

- Excellent LED Digit Driver
- DC Current Gain Specified — 50 mAdc to 500 mAdc

COMPLEMENTARY SILICON TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

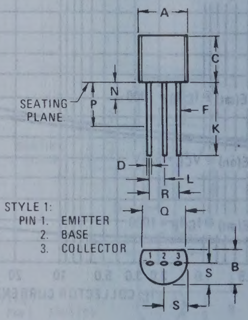
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	25	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	25	–	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)	I_{CES}	–	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	 50 80 30	 – – –	–
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	100	–	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

TYPICAL CHARACTERISTICS

NPN
MPS-D05

PNP
MPS-D55

FIGURE 1 – DC CURRENT GAIN

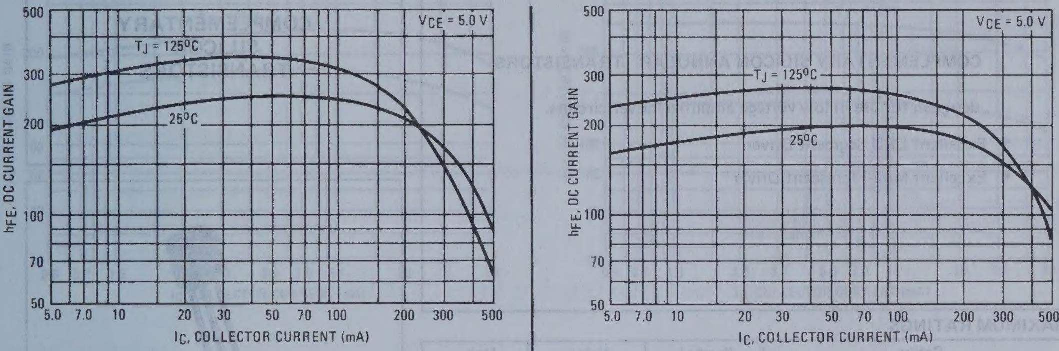


FIGURE 2 – "ON" VOLTAGES

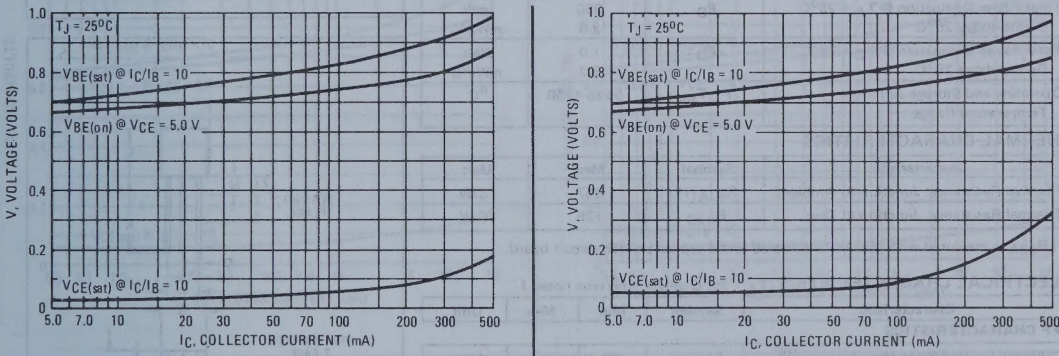


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

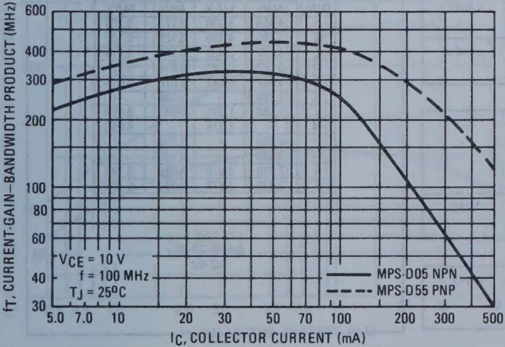
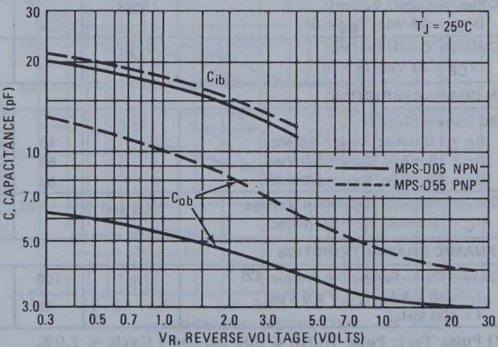


FIGURE 4 – CAPACITANCE



MPS-D06 NPN (SILICON)
MPS-D56 PNP

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for use in low voltage amplifier/driver circuits.

- Excellent LED Segment Driver
- Excellent Mini-Florescent Driver

COMPLEMENTARY SILICON TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +150	°C

THERMAL CHARACTERISTICS

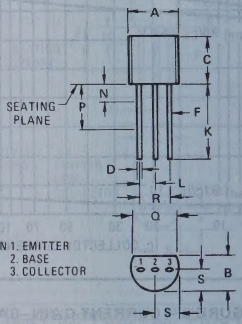
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (2) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	25	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current ($V_{CE} = 20$ Vdc, $V_{BE} = 0$)	I_{CES}	–	1.0	μAdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	–	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (2)	h_{FE}			–
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)		40	–	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)		50	–	
($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)		50	–	
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (2) ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	f_T	100	–	MHz

(2) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MPS-D06 NPN, MPS-D56 PNP (continued)

NPN
MPS-D06

PNP
MPS-D56

FIGURE 1 — DC CURRENT GAIN

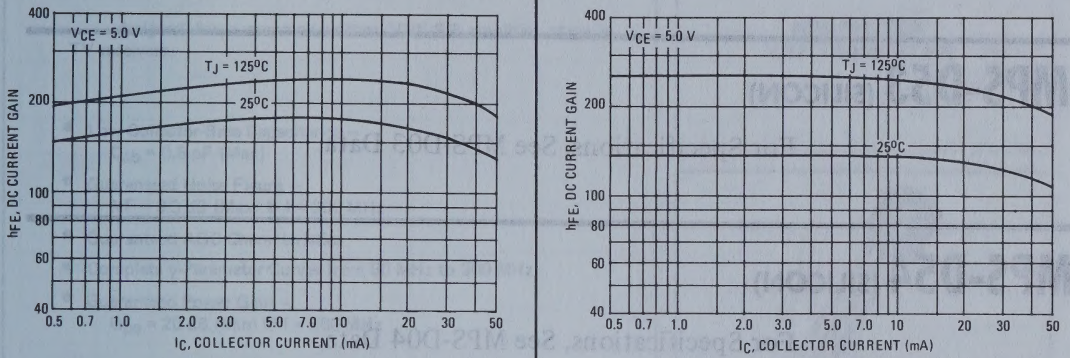


FIGURE 2 — "ON" VOLTAGES

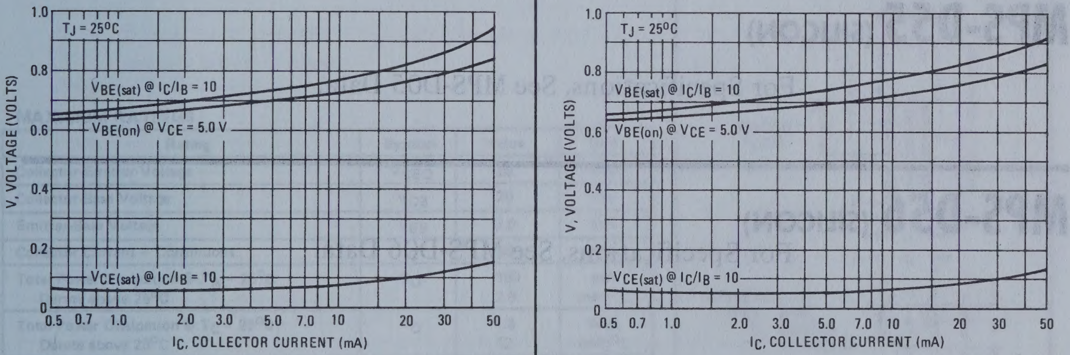


FIGURE 3 — CURRENT-GAIN — BANDWIDTH PRODUCT

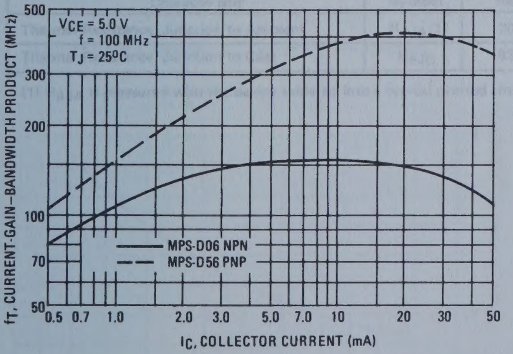
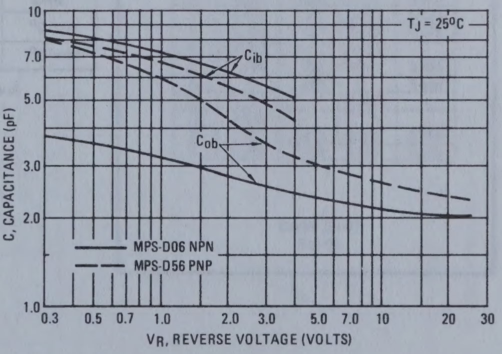


FIGURE 4 — CAPACITANCE



MPS-D51 (SILICON)

For Specifications, See MPS-D01 Data.

MPS-D52 (SILICON)

For Specifications, See MPS-D02 Data.

MPS-D53 (SILICON)

For Specifications, See MPS-D03 Data.

MPS-D54 (SILICON)

For Specifications, See MPS-D04 Data.

MPS-D55 (SILICON)

For Specifications, See MPS-D05 Data.

MPS-D56 (SILICON)

For Specifications, See MPS-D06 Data.

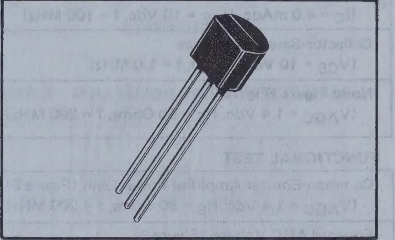
MPS-H02 (SILICON)

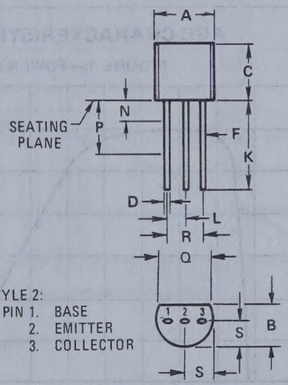
NPN SILICON ANNULAR TRANSISTOR

. . . designed for a common-emitter VHF-RF amplifier stage in TV receivers.

- Low Collector-Base Capacitance —
  C_{cb} = 0.5 pF (Max)
- Guaranteed Noise Figure —
  NF = 3.3 dB (Max) @ f = 200 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves from 50 MHz to 300 MHz
- Guaranteed Power Gain —
  G_{pe} = 20 dB (Min) @ f = 200 MHz

NPN SILICON
VHF TRANSISTOR





STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	^oC/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	^oC/mW

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	200	–
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	375	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.5	pF
Noise Figure (Figure 9) (V_{AGC} = 1.4 Vdc, R_S = 50 Ohms, f = 200 MHz)	NF	–	3.3	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 9) (V_{AGC} = 1.4 Vdc, R_S = 50 Ohms, f = 200 MHz)	G_{pe}	20	–	dB
Forward AGC Voltage (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 200 MHz)	V_{AGC}	4.0	5.0	Vdc

AGC CHARACTERISTICS (V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 200 MHz, See Figure 9)

FIGURE 1 — POWER GAIN

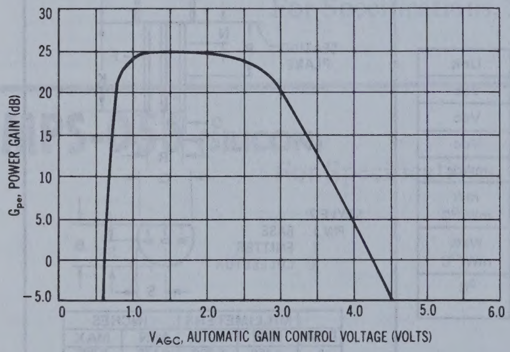
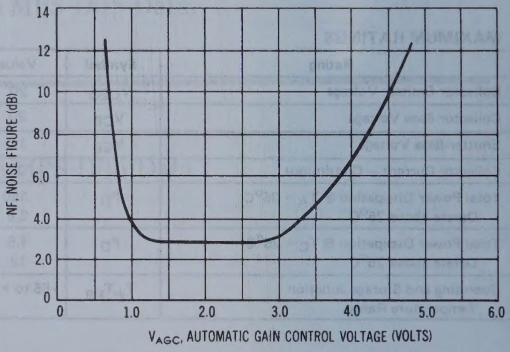


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 — INPUT ADMITTANCE

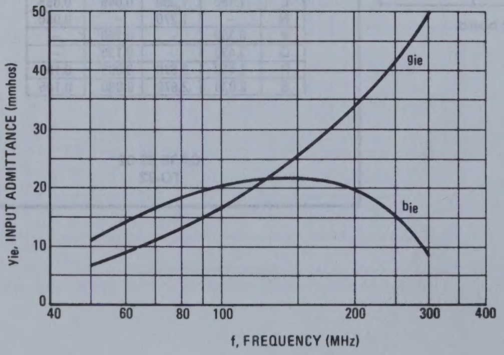
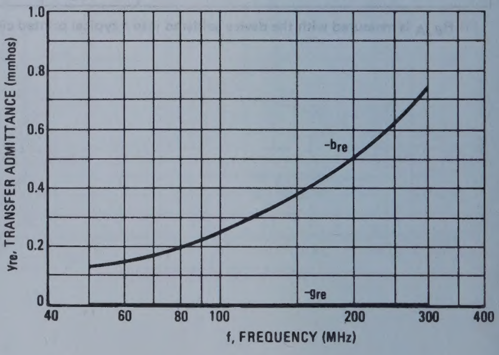


FIGURE 4 — REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS

(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

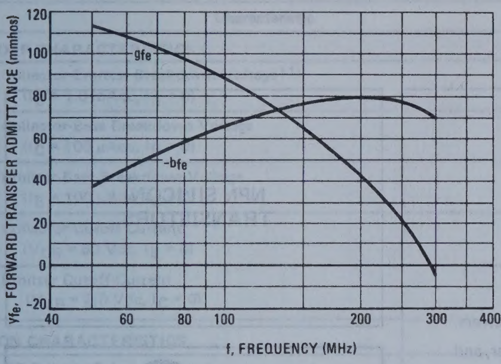


FIGURE 6 – OUTPUT ADMITTANCE

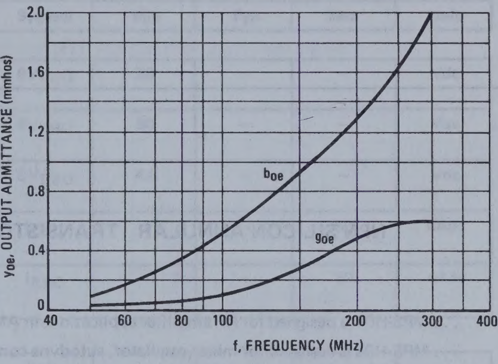


FIGURE 7 – DC CURRENT GAIN

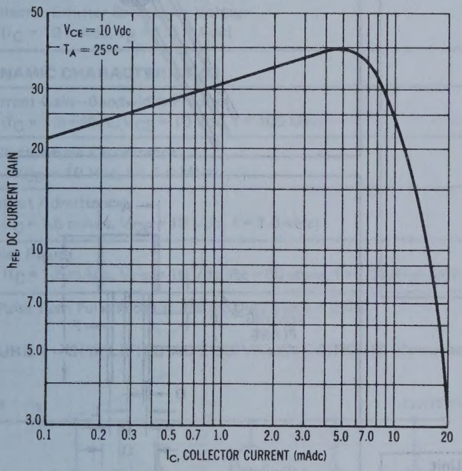


FIGURE 8 – COLLECTOR-BASE CAPACITANCE

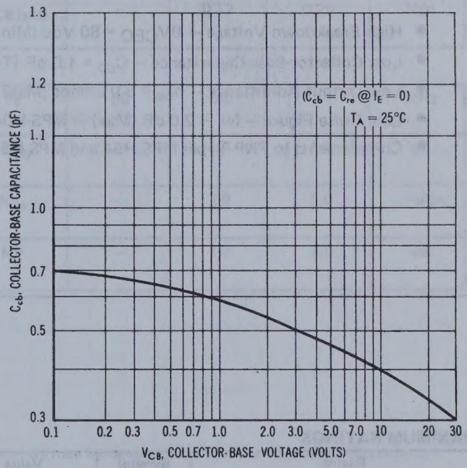
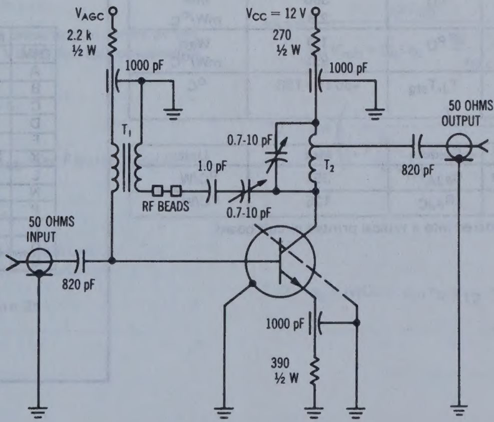


FIGURE 9 – 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



VAGC
2.2 k
½ W
1000 pF
VCC = 12 V
270
½ W
1000 pF
50 OHMS
OUTPUT
T1
0.7-10 pF
1.0 pF
T2
820 pF
RF BEADS
0.7-10 pF
50 OHMS
INPUT
820 pF
1000 pF
390
½ W

T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼″, L = ¾″

MPS-H04 (SILICON)
MPS-H05

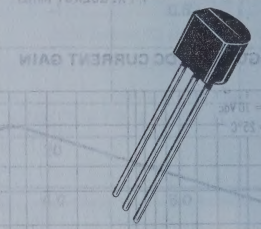
NPN SILICON ANNULAR TRANSISTORS

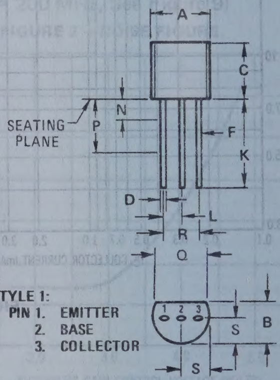
. . . MPS-H04 is designed for RF amplifier applications in AM receivers.

. . . MPS-H05 is designed for mixer, oscillator, autodyne converter, and IF amplifier applications in AM receivers.

- High Breakdown Voltage — BV_{CEO} = 80 Vdc (Min)
- Low Collector-Base Capacitance — C_{cb} = 1.0 pF (Typ)
- Low Output Admittance — h_{oe} = 5.0 μmhos (Max)
- Low Noise Figure — NF = 2.0 dB (Max) — MPS-H04
- Complements to PNP Types MPS-H54 and MPS-H55

NPN SILICON TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

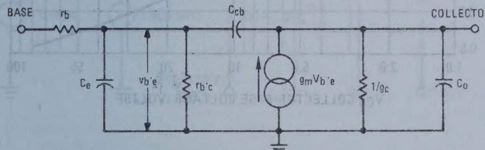
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	80	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 µAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc) MPS-H04 MPS-H05	h_{FE}	30 30	70 70	120 150	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.12	0.25	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	80	180	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	–	1.0	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	2.0	5.0	µmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz) MPS-H04	NF	–	1.7	2.0	dB

(1) Pulse Test: Pulse Width ⩽ 300 µs, Duty Cycle ⩽ 2.0%.

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-H04 and MPS-H05 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

$r_b' \approx 15$ Ohms

$r_e = 26\ \text{mV}/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

C_{cb}, See Figure 5

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\ h_{ob}$ (See Figures 3 and 6)

$C_o = 0.2$ pF

$r_{b'c} = (h_{fe} + 1)\ r_e$

Low frequency h parameters may be found from:

$h_{ie} = r_b' + r_{b'c}$

$h_{fe} \approx 1.1\ h_{FE}$ (See Figure 2)

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\ h_{ob}$

y Parameters may be determined from the following calculations:

$$y_{11} = \frac{1 + j\omega\,(C_e + C_{cb})\,r_{b'c}}{(r_b' + r_{b'c}) + j\omega\,(C_e + C_{cb})\,r_b'\,r_{b'c}}$$

$$y_{12} = \frac{j\omega\,C_{cb}}{j\omega\,(C_{cb} + C_e)\,r_b' + \dfrac{r_b' + r_{b'c}}{r_{b'c}}}$$

$$y_{21} = g_m\left(\frac{1}{\left(1 + \dfrac{r_b'}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\,r_b'}\right) - \frac{j\omega\,C_{cb}}{\left(1 + \dfrac{r_b'}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\,r_b'}$$

$$y_{22} = g_c + jwC_o - g_m\,r_b'\,y_{12} + \frac{\left(\dfrac{r_b' + r_{b'c}}{r_b'\,r_{b'c}} + j\omega\,C_e\right)\left(j\omega\,C_{cb}\right)}{\left(\dfrac{r_b' + r_{b'c}}{r_b'\,r_{b'c}} + j\omega\,(C_e + C_{cb})\right)}$$

ELECTRICAL CHARACTERISTICS (V_{CE} = 10 V, T_A = 25°C unless otherwise noted)

FIGURE 2 – NORMALIZED DC CURRENT GAIN

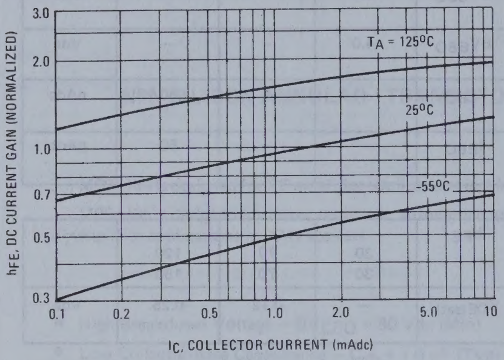


FIGURE 3 – "ON" VOLTAGES

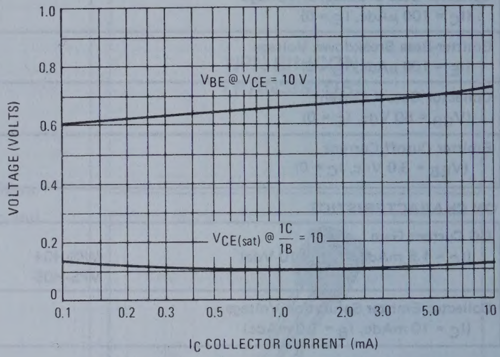


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

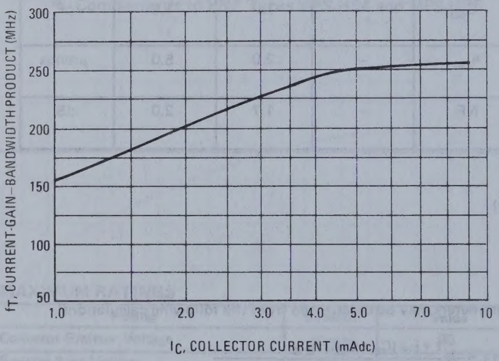


FIGURE 5 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

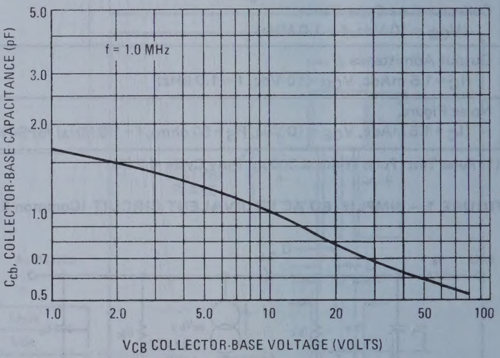


FIGURE 6 – OUTPUT ADMITTANCE

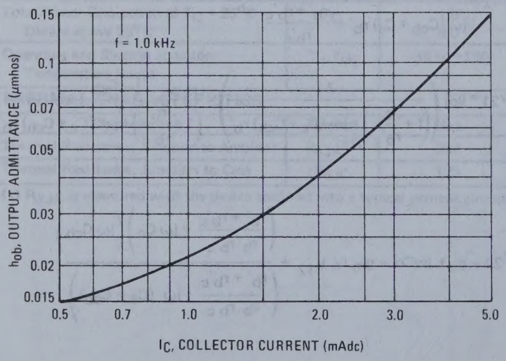
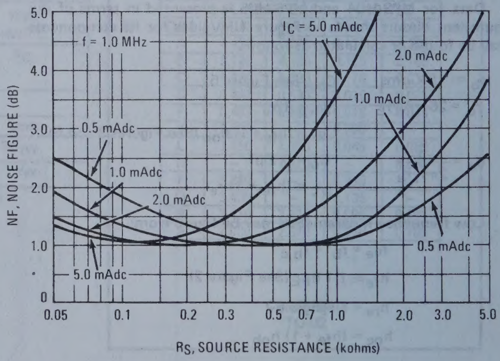
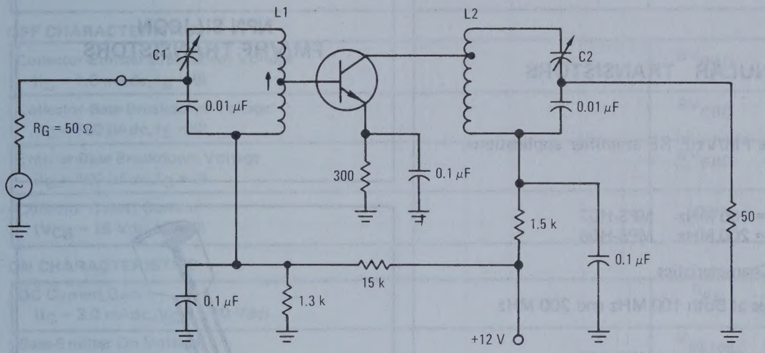


FIGURE 7 – NOISE FIGURE



AM RADIO DESIGN INFORMATION

FIGURE 8 – 1.0 MHz AMPLIFIER TEST CIRCUIT


L1
L2
C1
C2
0.01 μF
0.01 μF
R_G = 50 Ω
300
0.1 μF
1.5 k
50
0.1 μF
15 k
0.1 μF
1.3 k
+12 V

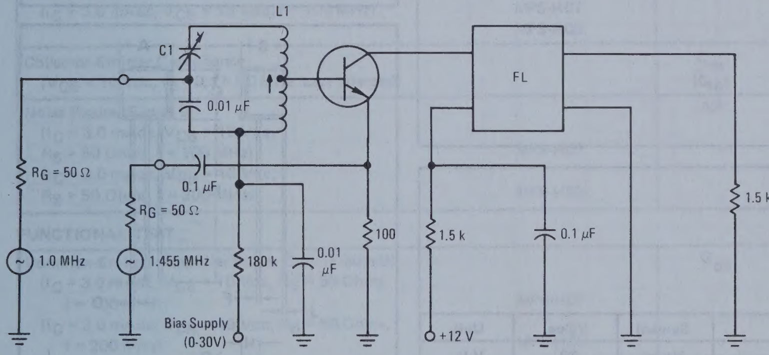
L1 90 turns of 7 x 41 Litz wire on 1/4″ form, tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, Q_u ≈ 130 Loaded Q, Q_L ≈ 60

L2 90 turns of 7 x 41 Litz wire on 1/4″ form, tapped 21 turns from high end. Turns ratio of coil ≈ 1.3, unloaded Q, Q_u ≈ 130, Loaded Q, Q_L ≈ 60

C1 25-280 pF Variable

C2 100-400 pF Variable

FIGURE 9 – 1.0 MHz MIXER TEST CIRCUIT


L1
C1
0.01 μF
FL
R_G = 50 Ω
0.1 μF
R_G = 50 Ω
100
1.5 k
0.1 μF
1.5 k
1.0 MHz
1.455 MHz
180 k
0.01 μF
Bias Supply
(0-30V)
+12 V

L1 90 turns of 7 x 41 Litz wire on 1/4″ form; tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, Q_u ≈ 130, Loaded Q, Q_L ≈ 60.

C1 25-280 pF Variable

FL 455 kHz Filter

FIGURE 10 – AMPLIFIER POWER GAIN

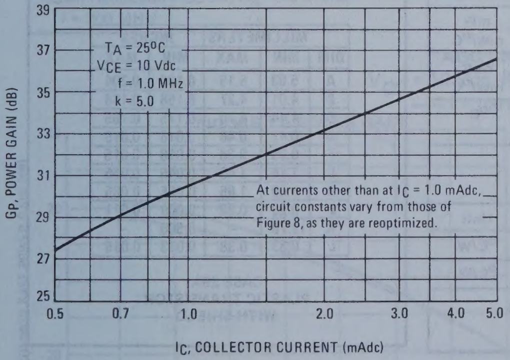
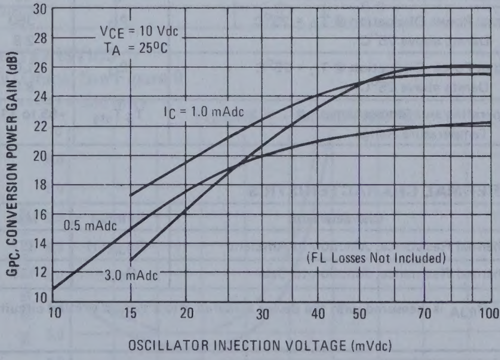


FIGURE 11 – CONVERSION POWER GAIN



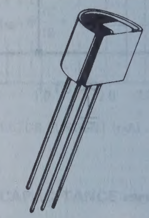
MPS-H07 (SILICON)
MPS-H08

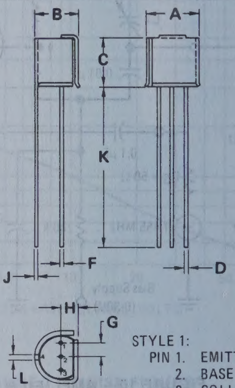
NPN SILICON ANNULAR TRANSISTORS

. . . designed for common-base FM/VHF RF amplifier applications.

- Guaranteed Noise Figure –
  NF = 3.2 dB (Max) @ f = 100 MHz MPS-H07
  = 3.5 dB (Max) @ f = 200 MHz MPS-H08
- Guaranteed Forward AGC Characteristics
- Complete y-Parameter Curves at Both 100 MHz and 200 MHz
- Guaranteed Power Gain –
  G_{pb} = 18 dB (Min) @ f = 100 MHz MPS-H07
  = 14 dB (Min) @ f = 200 MHz MPS-H08
- Low Feedback Capacitance Allowing Stable Unneutralized Operation

NPN SILICON FM/VHF TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.03	5.18	0.198	0.204
B	4.01	4.27	0.158	0.168
C	4.44	4.70	0.175	0.185
D	0.41	0.48	0.016	0.019
F	0.25	0.38	0.010	0.015
G	1.14	1.40	0.045	0.055
H	1.40	1.65	0.055	0.065
J	0.23	0.28	0.009	0.011
K	12.70	–	0.500	–
L	0.33	0.38	0.013	0.015

CASE 29A
PLASTIC TRANSISTOR
WITH SHIELD

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	30	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	–	–
Base-Emitter On Voltage (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS-H07 MPS-H08	f_T	400 500	– –	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)		C_{ce} (C_{rb})	–	0.3	pF
Noise Figure (Figure 9) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 100 MHz)	MPS-H07	NF	–	3.2	dB
(I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	MPS-H08		–	3.5	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 9) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms f = 100 MHz)	MPS-H07	G_{pb}	18	–	dB
(I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	MPS-H08		14	–	
Forward AGC Current (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms f = 100 MHz)	MPS-H07	I_{AGC}	5.0	8.0	mAdc
(Gain Reduction = 30 dB, R_S = 50 Ohms, f = 200 MHz)	MPS-H08		5.0	8.0	

AGC CHARACTERISTICS

V_{CC} = 10 Vdc, R_S = 50 Ohms, See Figure 9

—— f = 100 MHz – – – f = 200 MHz

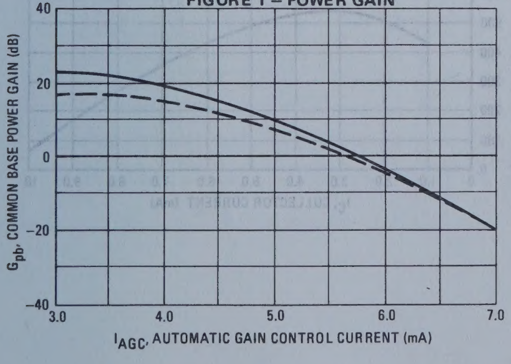


FIGURE 1 – POWER GAIN

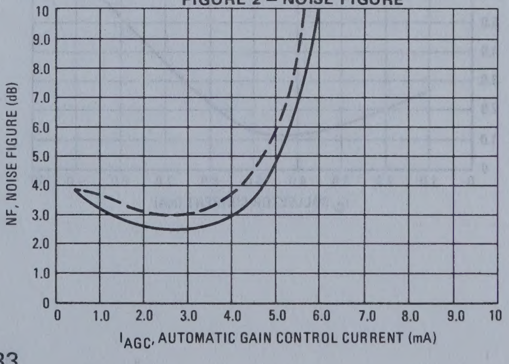


FIGURE 2 – NOISE FIGURE

COMMON-BASE y PARAMETERS

$V_{CB} = 10$ Vdc, $T_A = 25^oC$

—— f = 100 MHz – – – f = 200 MHz

FIGURE 3 – INPUT ADMITTANCE

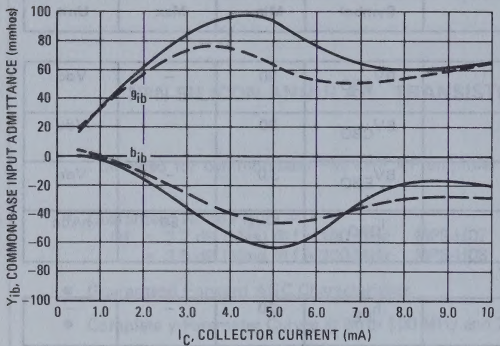


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

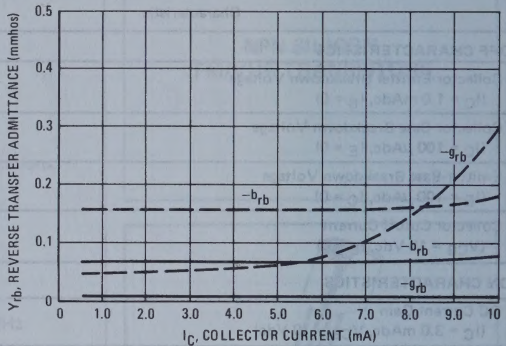


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

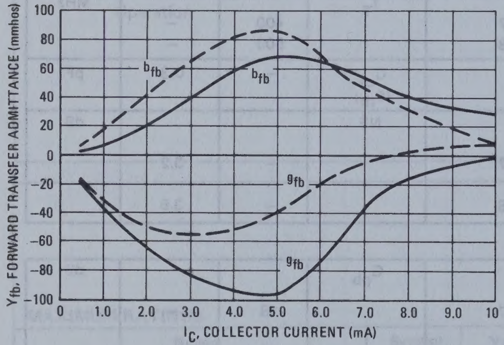


FIGURE 6 – OUTPUT ADMITTANCE

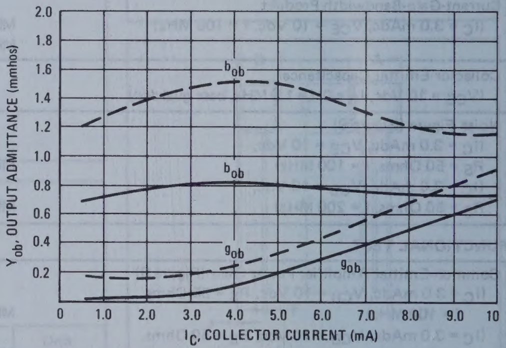


FIGURE 7 – COLLECTOR-BASE TIME CONSTANT

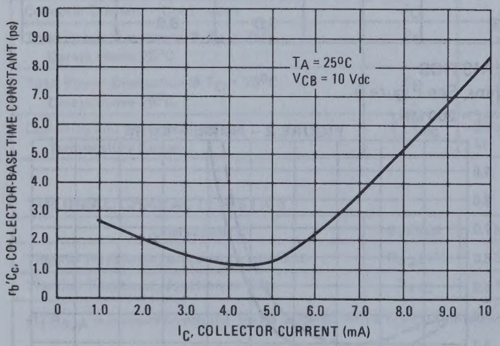


FIGURE 8 – CURRENT-GAIN BANDWIDTH PRODUCT

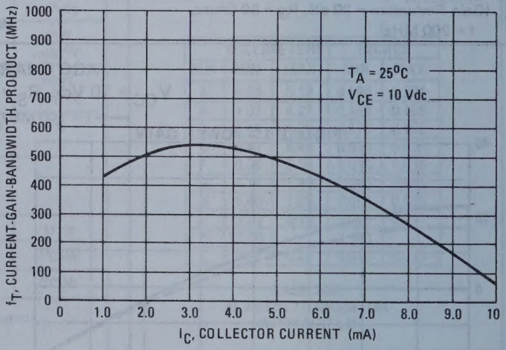
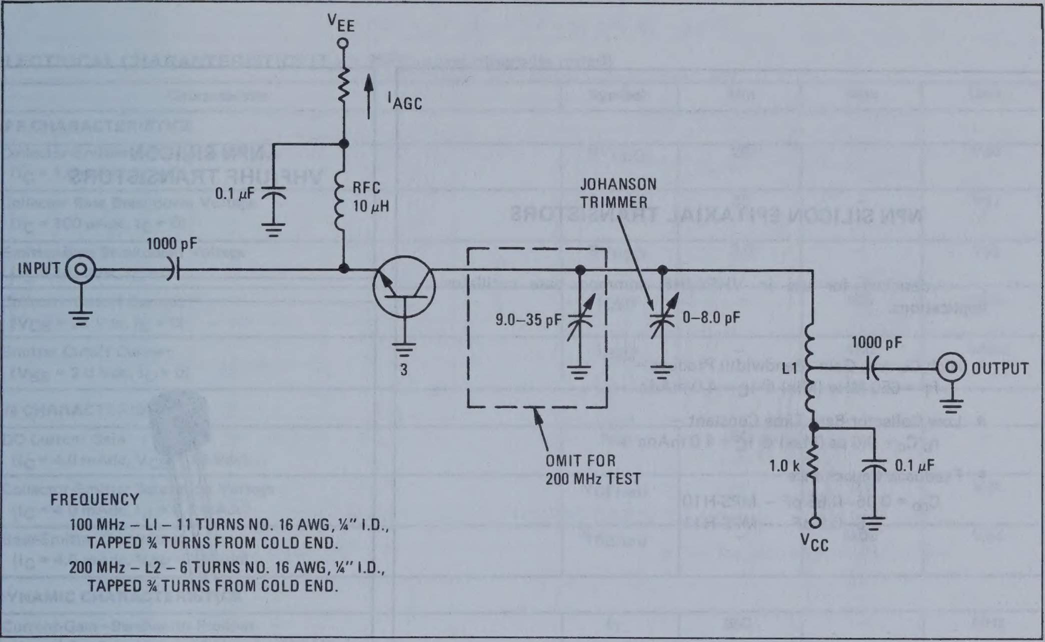


FIGURE 9 – 100-MHz AND 200-MHz COMMON-BASE AMPLIFIER


VEE
IAGC
0.1 μF
RFC
10 μH
1000 pF
INPUT
3
JOHANSON
TRIMMER
9.0–35 pF
0–8.0 pF
1000 pF
L1
OUTPUT
OMIT FOR
200 MHz TEST
1.0 k
0.1 μF
VCC
FREQUENCY
100 MHz – LI – 11 TURNS NO. 16 AWG, ¼" I.D.,
TAPPED ¾ TURNS FROM COLD END.
200 MHz – L2 – 6 TURNS NO. 16 AWG, ¼" I.D.,
TAPPED ¾ TURNS FROM COLD END.

MPS-H10 (SILICON)
MPS-H11

NPN SILICON VHF/UHF TRANSISTORS

NPN SILICON EPITAXIAL TRANSISTORS

. . . designed for use in VHF/UHF common base oscillator applications.

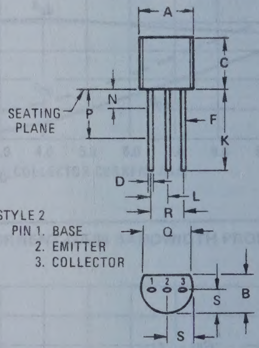
- High Current-Gain–Bandwidth Product – f_T = 650 MHz (Min) @ I_C = 4.0 mAdc
- Low Collector-Base Time Constant – $r_b'C_c$ = 9.0 ps (Max) @ I_C = 4.0 mAdc
- Feedback Capacitance –
  C_{rb} = 0.35–0.65 pF – MPS-H10
  0.6–0.9 pF – MPS-H11

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W



STYLE 2
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	–	–
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	0.95	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.7	pF
Common-Base Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) MPS-H10 MPS-H11	C_{rb}	0.35 0.6	0.65 0.9	pF
Collector-Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	9.0	ps

COMMON-BASE y PARAMETERS versus FREQUENCY

(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

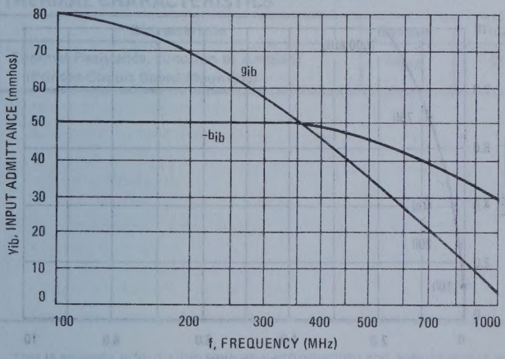
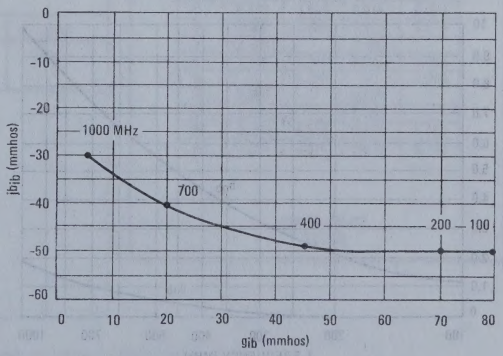


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY

(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

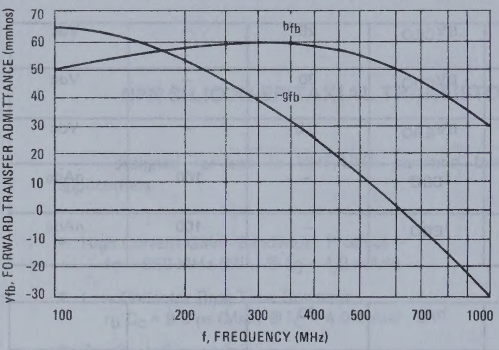
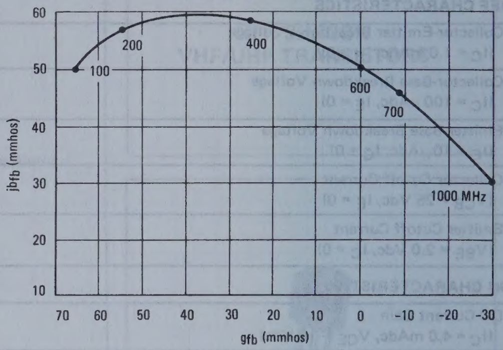


FIGURE 4 – POLAR FORM



y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

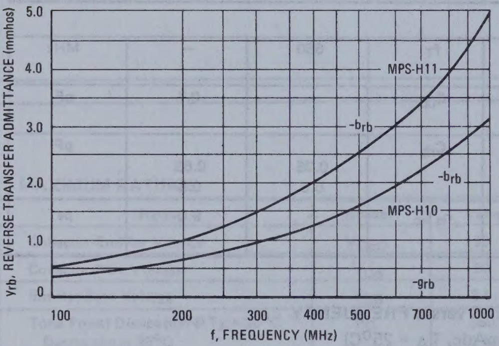
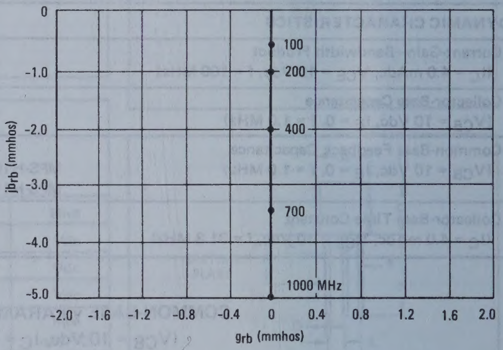


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

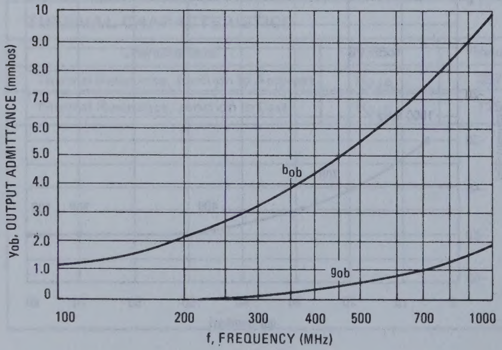
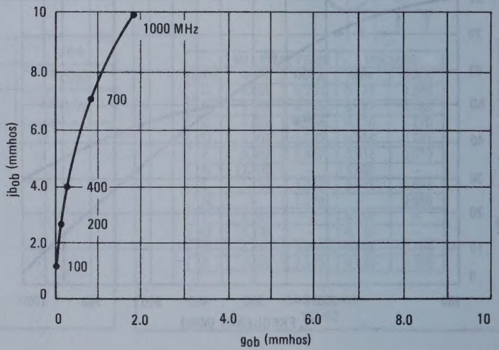


FIGURE 8 – POLAR FORM



MPS-H17 (SILICON)

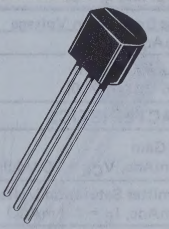
Advance Information

NPN SILICON ANNULAR TRANSISTORS

. . . designed for CATV converter applications.

- Low Collector-Base Capacitance — C_{cb} = 0.9 pF (Max)
- High Current-Gain — Bandwidth Product — f_T = 800 MHz (Min) @ I_C = 5.0 mAdc
- Low Noise Figure — NF = 6.0 dB (Max) @ f = 200 MHz

NPN SILICON TRANSISTORS

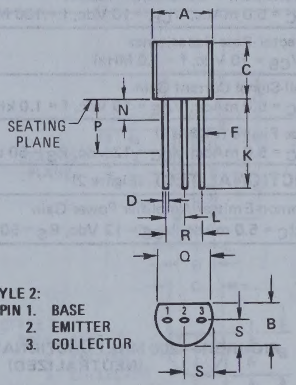


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	$R_{\theta JA}$	200	°C/W



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

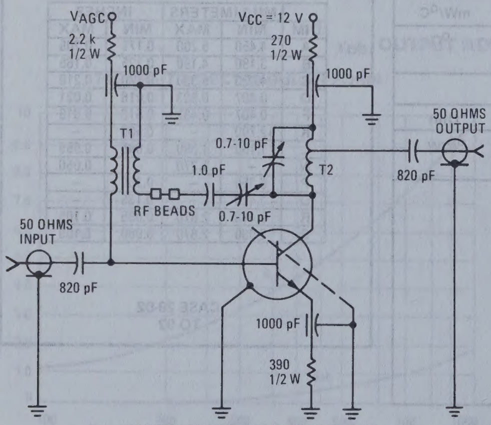
CASE 29-02
TO-92

This is advance information on a new introduction and specifications are subject to change without notice.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	–	250	–
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	800	–	–	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, f = 1.0 MHz)	C_{cb}	0.3	–	0.9	pF
Small-Signal Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)	h_{fe}	30	–	–	–
Noise Figure (Figure 1) ($I_C = 5.0$ mAdc, $V_{CC} = 12$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	NF	–	–	6.0	dB
FUNCTIONAL TEST (Figure 2)					
Common-Emitter Amplifier Power Gain ($I_C = 5.0$ mAdc, $V_{CC} = 12$ Vdc, $R_S = 50$ ohms, f = 200 MHz)	G_{pe}	–	24	–	dB

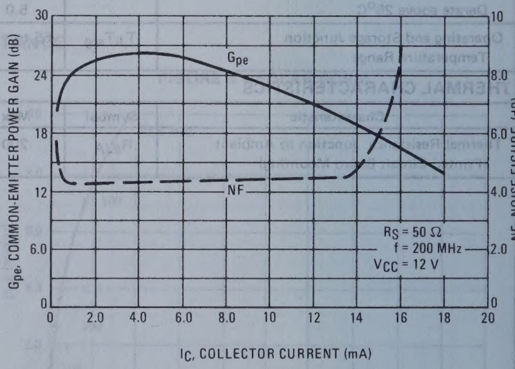
FIGURE 1 – 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



VAGC
2.2 k
1/2 W
1000 pF
VCC = 12 V
270
1/2 W
1000 pF
T1
0.7-10 pF
1.0 pF
T2
RF BEADS
0.7-10 pF
50 OHMS OUTPUT
820 pF
50 OHMS INPUT
820 pF
1000 pF
390
1/2 W

T1 = FERRITE CORE INDIANA GEN. CORP. F-684
T2 = 6 TURNS #16 BUSS WIRE, ID = 1/4", L = 3/4"

FIGURE 2 – TYPICAL COMMON EMITTER POWER GAIN AND NOISE FIGURE



MPS-H19 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain — 15 dB (Min) @ 200 MHz
- Low Collector-Base Capacitance — C_{cb} = 0.65 pF (Max)
- High Current-Gain—Bandwidth Product — f_T = 300 MHz (Min)
- Complete y-Parameters @ 4.0 mA

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

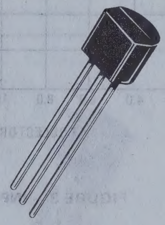
THERMAL CHARACTERISTICS

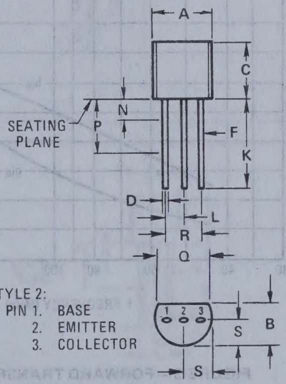
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	45	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.65	pF
Conversion Gain (Figures 1 and 2) (213 MHz to 45 MHz) (I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)	G_{PC}	15	–	dB

NPN SILICON VHF TRANSISTOR





STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 2)

(f_{sig} = 213 MHz, f_{if} = 45 MHz, B.W. = 6.0 MHz)

FIGURE 1 – CONVERSION GAIN

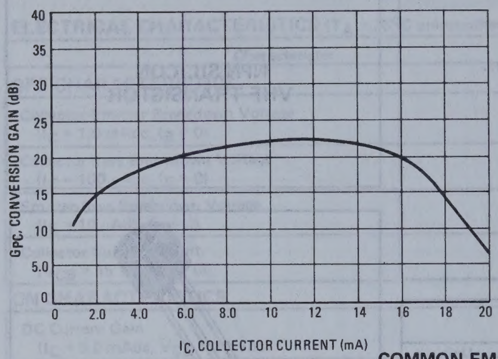
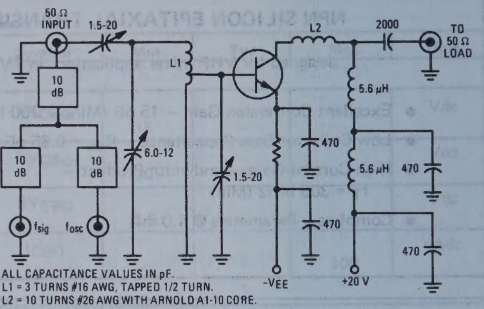


FIGURE 2 – VHF MIXER TEST CIRCUIT



50 Ω INPUT
1.5-20
L1
10 dB
10 dB
10 dB
6.0-12
1.5-20
f_sig
f_osc
470
470
L2
2000
TO 50 Ω LOAD
5.6 μH
5.6 μH
470
470
-VEE
+20 V

ALL CAPACITANCE VALUES IN pF.
L1 = 3 TURNS #16 AWG, TAPPED 1/2 TURN.
L2 = 10 TURNS #26 AWG WITH ARNOLD A1-10 CORE.

COMMON-EMITTER y PARAMETERS

(V_{CE} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

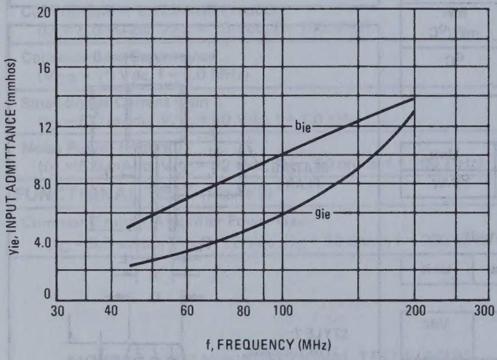


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

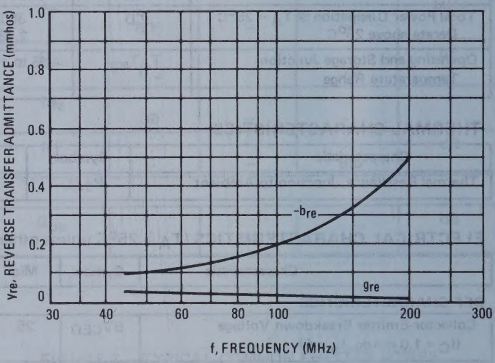


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

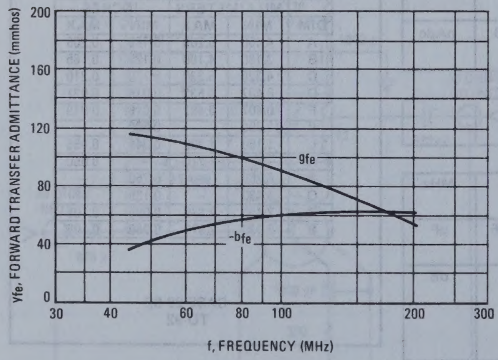
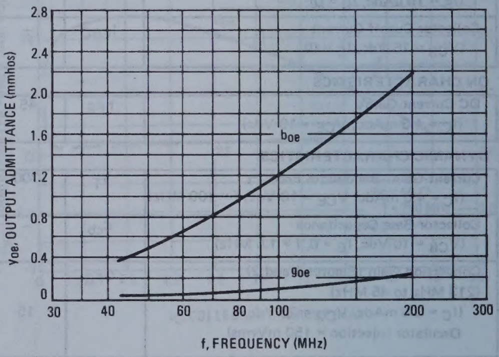


FIGURE 6 – OUTPUT ADMITTANCE



MPS-H20 (SILICON)

NPN SILICON EPITAXIAL TRANSISTORS

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain — 23 dB (Typ)
- Low Collector-Base Capacitance — C_{cb} = 0.65 pF (Max)
- High Current-Gain—Bandwidth Product — f_T = 400 MHz (Min)
- Complete y-Parameter Curves from 50 to 300 MHz
- One-Piece, Injection Molded Unibloc Package

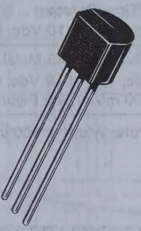
MAXIMUM RATINGS

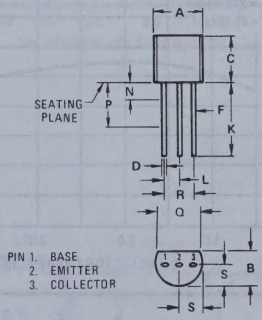
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watt mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^oC/W$

NPN SILICON VHF TRANSISTOR





	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	–	–	–
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.5	0.65	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	10	–	ps
Conversion Gain (213 to 45 MHz) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, Oscillator Injection = 200 mVdc, See Figures 1, 2 and 9)	G_{PC}	18	23	–	dB

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 – VARIATION WITH COLLECTOR CURRENT

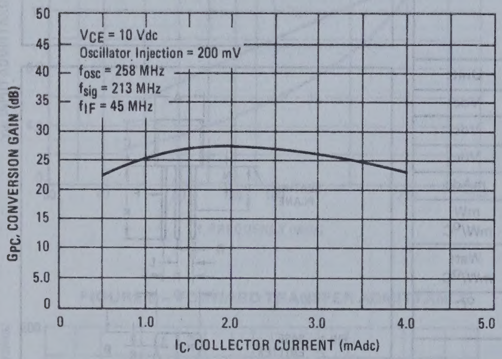
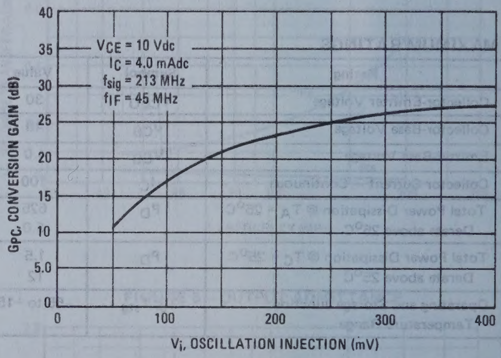


FIGURE 2 – VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

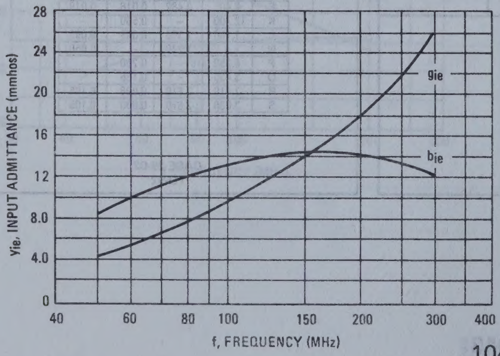
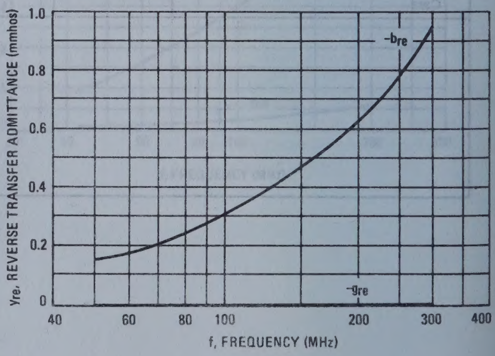


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS

(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

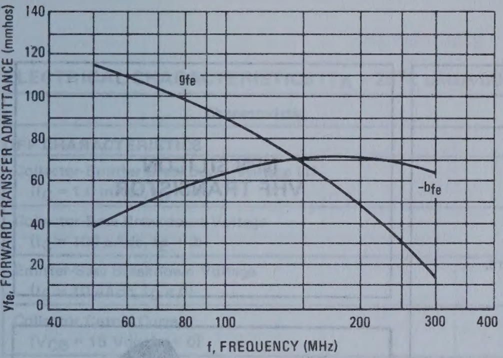


FIGURE 6 – OUTPUT ADMITTANCE

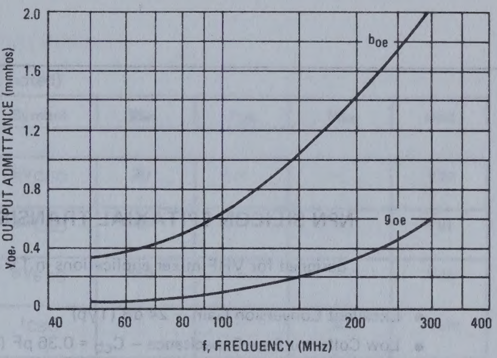


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

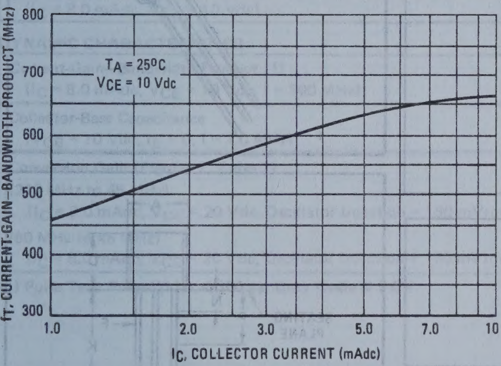


FIGURE 8 – CAPACITANCES

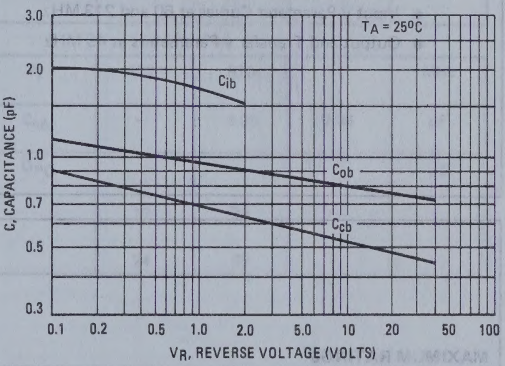
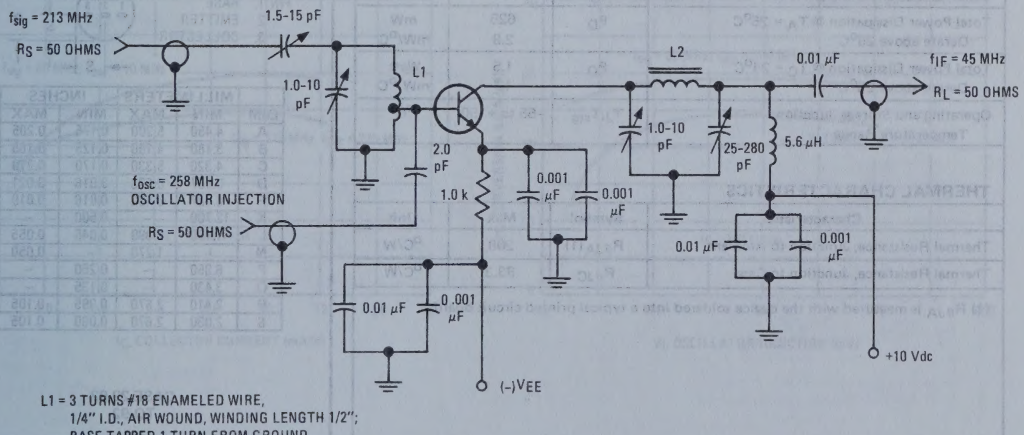


FIGURE 9 – MIXER TEST CIRCUIT


fsig = 213 MHz
RS = 50 OHMS
1.5-15 pF
1.0-10 pF
L1
2.0 pF
fosc = 258 MHz
OSCILLATOR INJECTION
RS = 50 OHMS
1.0 k
0.001 μF
0.001 μF
0.01 μF
0.001 μF
(–)VEE
L2
1.0-10 pF
25-280 pF
5.6 μH
0.01 μF
fIF = 45 MHz
RL = 50 OHMS
0.01 μF
0.001 μF
+10 Vdc

L1 = 3 TURNS #18 ENAMELED WIRE,
1/4" I.D., AIR WOUND, WINDING LENGTH 1/2";
BASE TAPPED 1 TURN FROM GROUND.

L2 = 10 TURNS #26 INSULATED WIRE, WOUND
ON 1/4" I.D. COIL FORM, ARNOLD PART
NO. A1-10 IRON POWDER CORE.

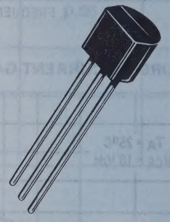
MPS-H24 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain — 24 dB (Typ)
- Low Collector-Base Capacitance — C_{cb} = 0.36 pF (Max)
- High Current-Gain—Bandwidth Product — f_T = 400 MHz (Min)
- Input y-Parameter Curves at 60 and 213 MHz
- Output and Transfer y-Parameters at 45 MHz

NPN SILICON VHF TRANSISTOR



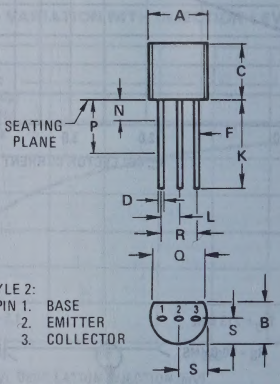
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 2.8	mW mW/^{o}C
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watt mW/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^{o}C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	^{o}C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	^{o}C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.25	0.36	pF
Conversion Gain (Figures 1, 2 and 7)	G_{PC}				dB
(213 MHz to 45 MHz)					
(I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)		19	24	–	
(60 MHz to 45 MHz)					
(I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)		24	29	–	

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 7)
(V_{CC} = 20 Vdc, R_S = R_L = 50 Ohms, f_{if} = 44 MHz, B.W. = 6.0 MHz)

FIGURE 1 — CONVERSION GAIN versus COLLECTOR CURRENT

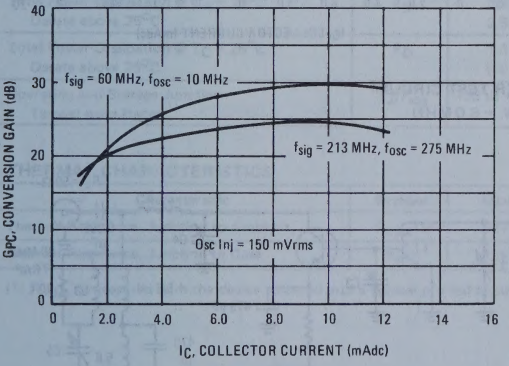
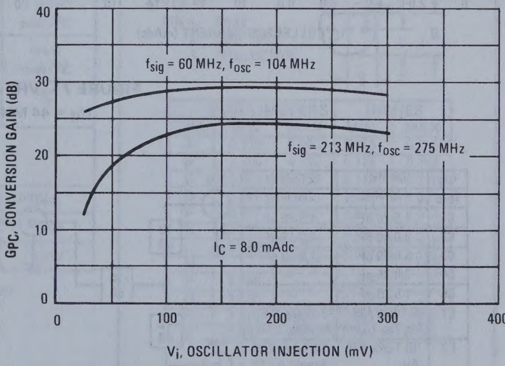


FIGURE 2 — CONVERSION GAIN versus INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

(V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

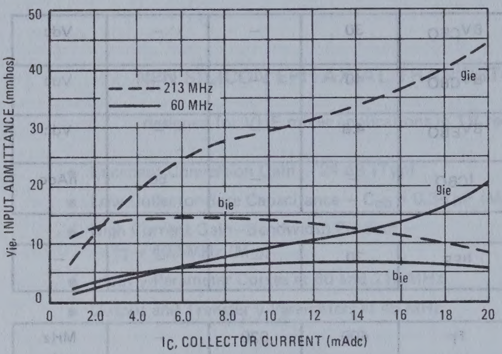


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

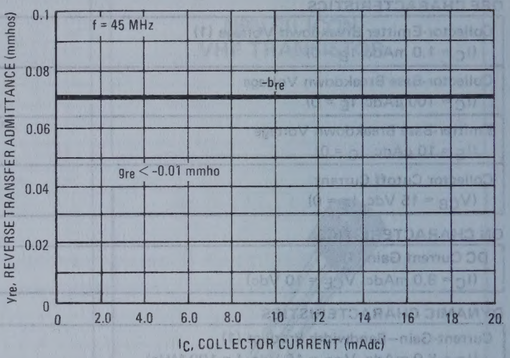


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

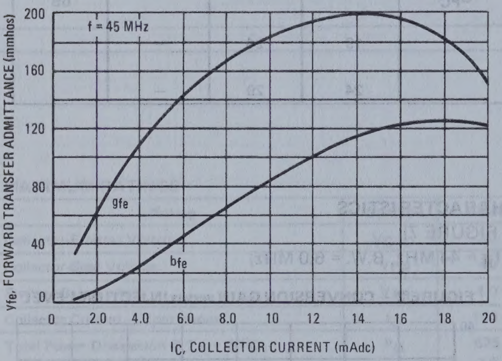


FIGURE 6 – OUTPUT ADMITTANCE

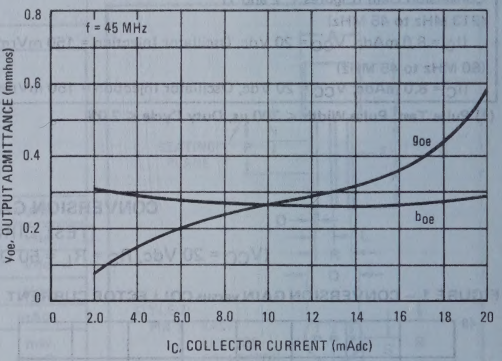
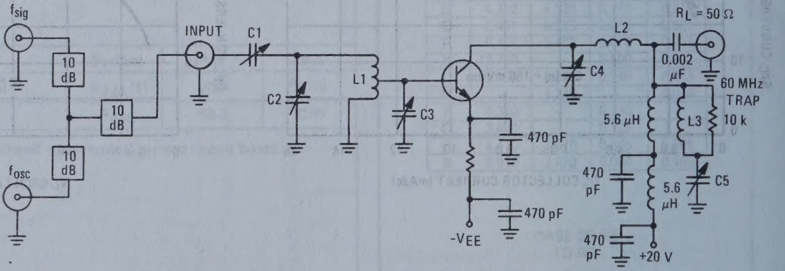


FIGURE 7 – VHF MIXER TEST CIRCUIT

(f_{if} = 44 MHz, B.W. = 6.0 MHz)

f_{sig}	60 MHz	213 MHz
f_{osc}	105 MHz	258 MHz
C1	1.5-20 pF	1.5-20 pF
C2	8.0-60 pF	6.0-12 pF
C3	8.0-60 pF	1.5-20 pF
C4	3.0-35 pF	–
C5	1.5-20 pF	–
L1	5 Turns #26 Air, Tap 1 Turn	3 Turns #16 Air, Tap ½ Turn
L2	10 Turns #26 Air	10 Turns #26 Arnold A1-10 Core
L3	Ohmite Z235	–



f_{sig}
10 dB
10 dB
10 dB
f_{osc}
INPUT
C1
C2
L1
C3
C4
470 pF
470 pF
$-V_{EE}$
L2
R_L = 50 Ω
0.002 μF
60 MHz TRAP
5.6 μH
L3
10 k
470 pF
5.6 μH
C5
470 pF
+20 V

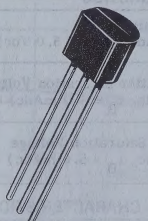
MPS-H30 (SILICON)
MPS-H31

NPN SILICON ANNULAR TRANSISTORS

. . . designed for first and second video IF stages in TV receivers.

- Guaranteed Noise Figure —
  NF = 6.0 dB (Max) at 45 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves at 45 MHz
- Guaranteed Power Gain —
  G_{pe} = 22.5 dB (Min) (Unneutralized) at 45 MHz

NPN SILICON IF AMPLIFIER TRANSISTORS



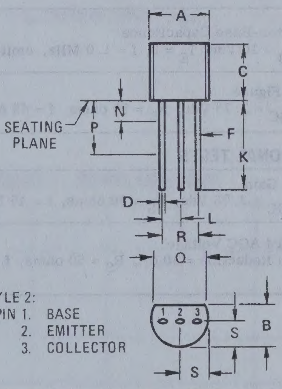
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc

ON CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	0.96	Vdc

SMALL-SIGNAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	C_{cb}	-	0.65	pF
Noise Figure (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 9)	NF	-	6.0	dB

FUNCTIONAL TESTS

Characteristic		Symbol	Min	Max	Unit
Power Gain (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 9)		G_{pe}	22.5	31	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 45 MHz, Figure 9)	MPS-H30 MPS-H31	V_{AGC}	4.4 5.2	5.4 6.2	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 45 MHz, See Figure 9

FIGURE 1 — POWER GAIN

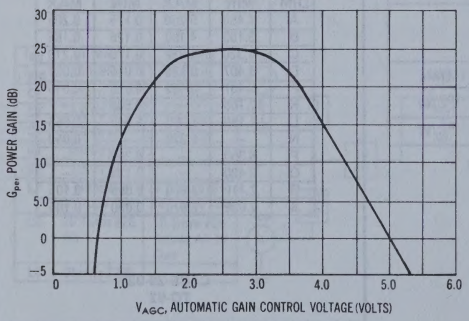
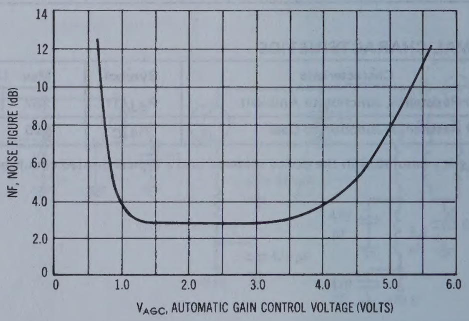


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C, f = 45 MHz

FIGURE 3 — INPUT ADMITTANCE

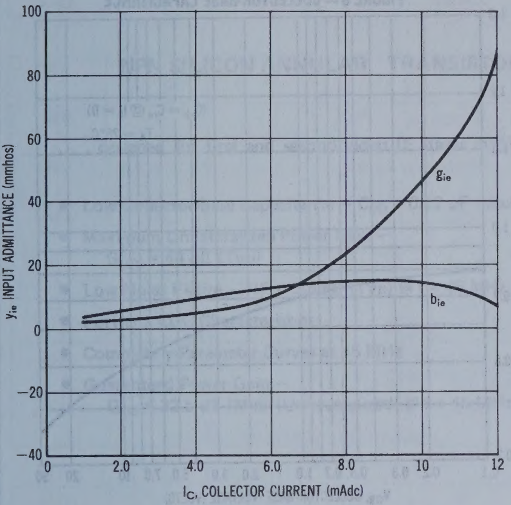


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

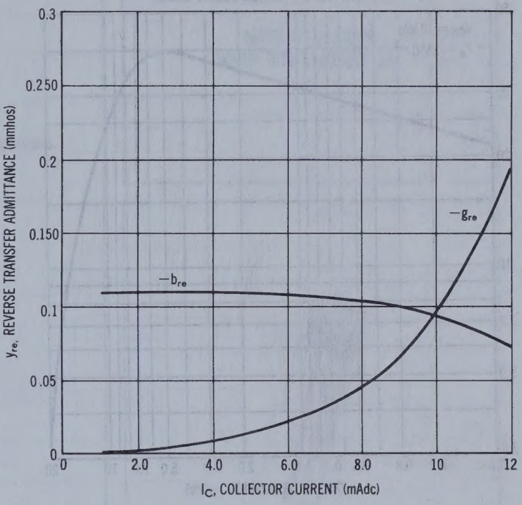


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

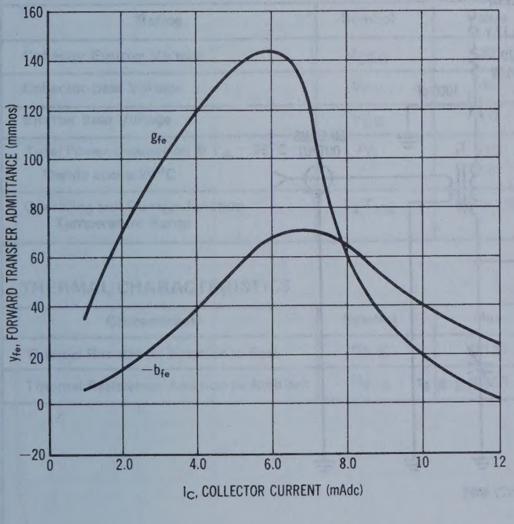


FIGURE 6 — OUTPUT ADMITTANCE

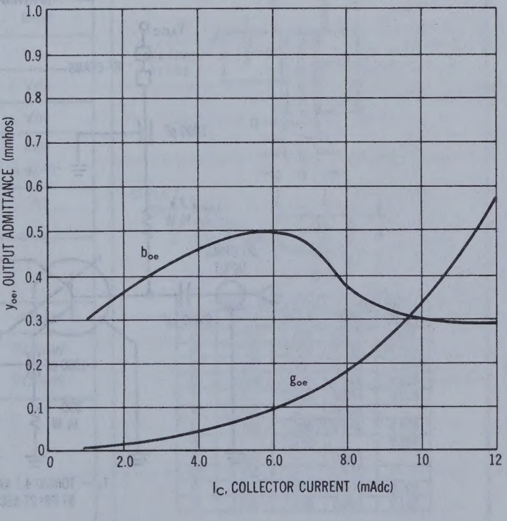


FIGURE 7 — DC CURRENT GAIN

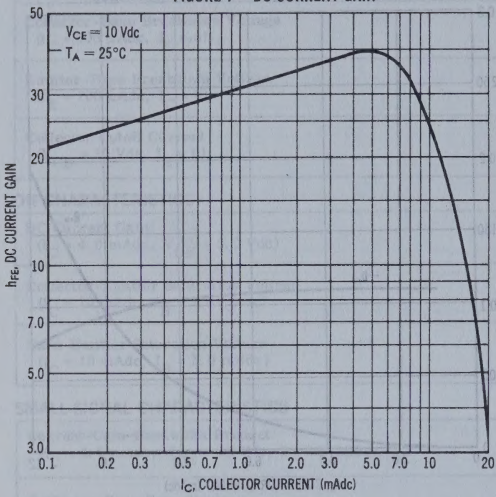


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

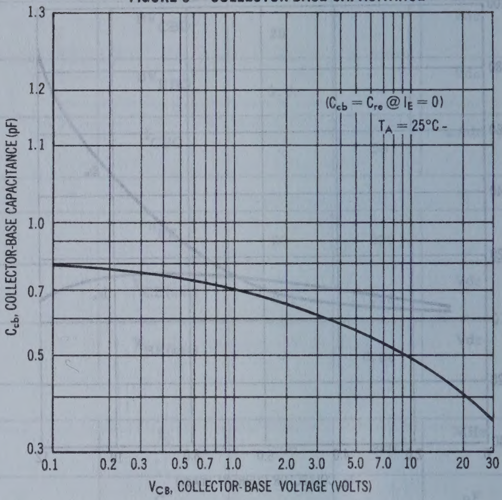
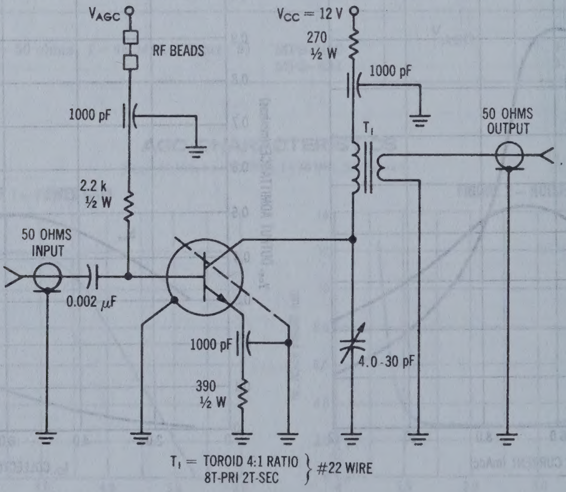


FIGURE 9 — 45 MHz FUNCTIONAL TEST CIRCUIT
(UNNEUTRALIZED)


V_{AGC}
RF BEADS
1000 pF
2.2 k
½ W
50 OHMS
INPUT
0.002 μF
1000 pF
390
½ W
V_{CC} = 12 V
270
½ W
1000 pF
T_1
50 OHMS
OUTPUT
4.0-30 pF
T_1 = TOROID 4:1 RATIO
8T-PRI 2T-SEC
#22 WIRE

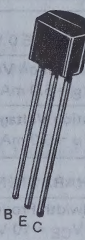
MPS-H32 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for first and second video IF stages in TV receivers.

- Low Collector-Base Capacitance – C_{cb} = 0.22 pF (Max)
- Maximum Unilateralized Power Gain –
  G_{um} = 44 dB (Typ)
- Low Noise Figure – NF = 3.3 dB (Typ) @ f = 45 MHz
- Forward AGC Characteristics
- Complete y-Parameter Curves at 45 MHz
- Guaranteed Power Gain –
  G_{pe} = 22.5 dB (Min) (Unneutralized) @ f = 45 MHz

NPN SILICON
VHF TRANSISTOR

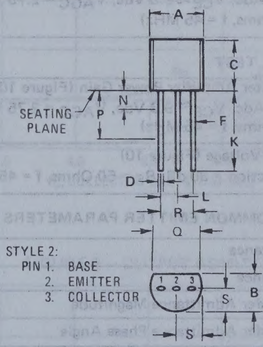


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.137	°C/mW
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.357	°C/mW



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 10$ Vdc, $I_E = 0$)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 4.0$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	27	35	200	–
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 5.0$ mAdc)	$V_{CE(sat)}$	–	1.5	3.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 5.0$ mAdc)	$V_{BE(sat)}$	–	0.9	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product ($I_C = 4.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	440	–	MHz
Collector-Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz) (Emitter Guarded)	C_{cb}	–	0.2	0.22	pF
Noise Figure (Figure 10) ($I_E \approx 4.0$ mAdc, $V_{CE} \approx 9.3$ Vdc, $V_{AGC} = 2.75$ Vdc, $R_S = 50$ Ohms, f = 45 MHz)	NF	–	3.3	–	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 10) ($I_E \approx 4.0$ mAdc, $V_{CE} \approx 9.3$ Vdc, $V_{AGC} = 2.75$ Vdc, $R_S = 50$ Ohms, f = 45 MHz)	G_{pe}	22.5	25	–	dB
Forward AGC Voltage (Figure 10) (Gain Reduction = 30 dB, $R_S = 50$ Ohms, f = 45 MHz)	V_{AGC}	–	5.5	–	Vdc
SUMMARY-COMMON EMITTER PARAMETERS ($V_{CE} = 10$ Vdc, $I_C = 4.0$ mAdc, f = 45 MHz)					
Input Conductance	g_{ie}	–	6.0	–	mmhos
Input Capacitance	C_{ie}	–	33	–	pF
Forward Transfer Admittance Magnitude	$\lvert y_{fe} \rvert$	–	110	–	mmhos
Forward Transfer Admittance Phase Angle	$\angle y_{fe}$	–	-22	–	Degrees
Feedback Capacitance	C_{re}	–	0.2	–	pF
Output Conductance	g_{oe}	–	20	–	μmhos
Output Capacitance	C_{oe}	–	1.4	–	pF
Maximum Unilateralized Power Gain $G_{um} = \frac{\lvert y_{fe} \rvert^2}{4\, g_{ie}\, g_{oe}}$	G_{um}	–	44	–	dB

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 45 MHz, See Figure 10

FIGURE 1 – POWER GAIN

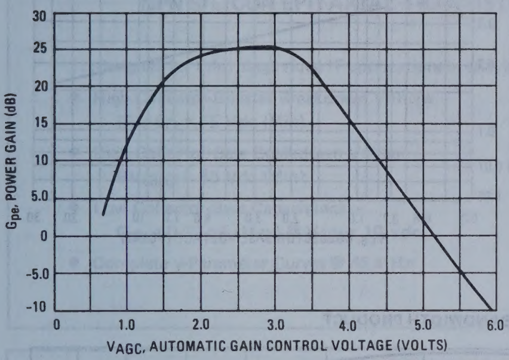
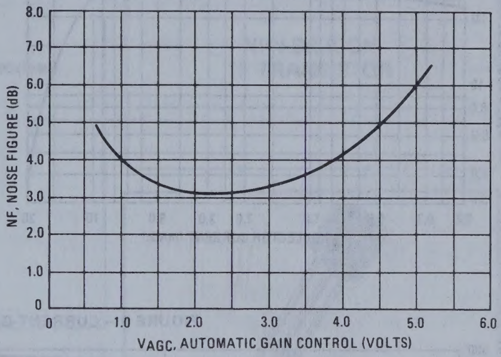


FIGURE 2 – NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 10 Vdc, f = 45 MHz, T_A = 25°C

FIGURE 3 – INPUT ADMITTANCE

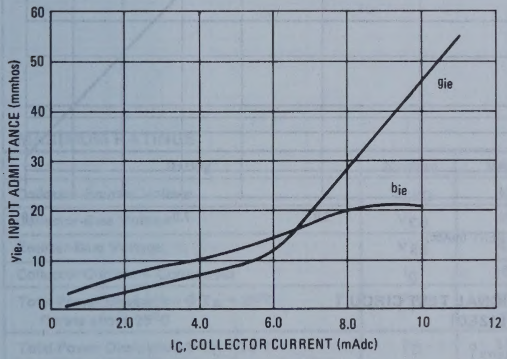


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

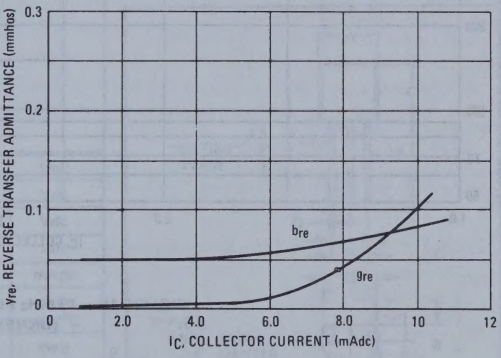


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

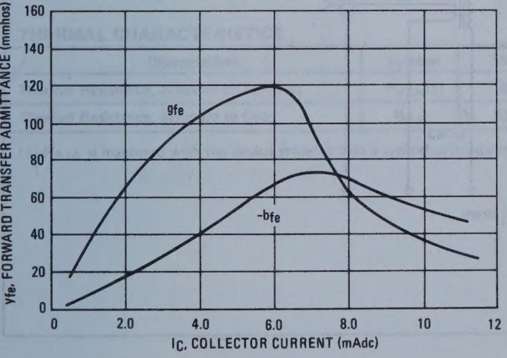


FIGURE 6 – OUTPUT ADMITTANCE

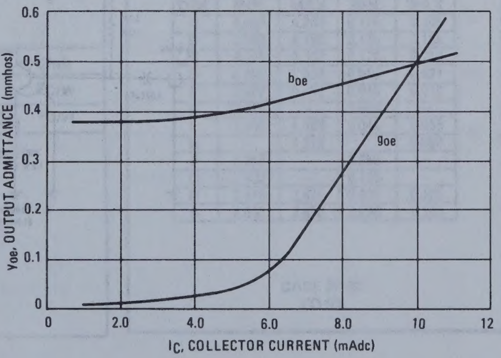


FIGURE 7 – DC CURRENT GAIN

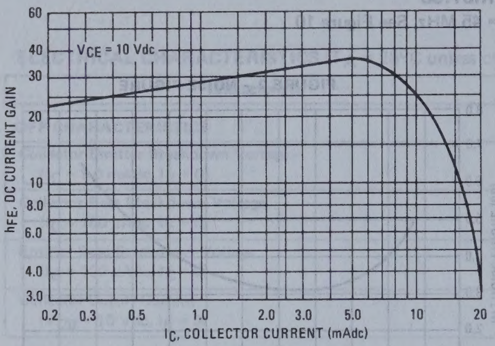


FIGURE 8 – COLLECTOR-BASE CAPACITANCE

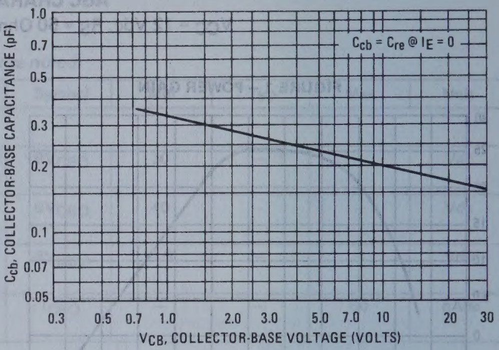


FIGURE 9 – CURRENT-GAIN–BANDWIDTH PRODUCT

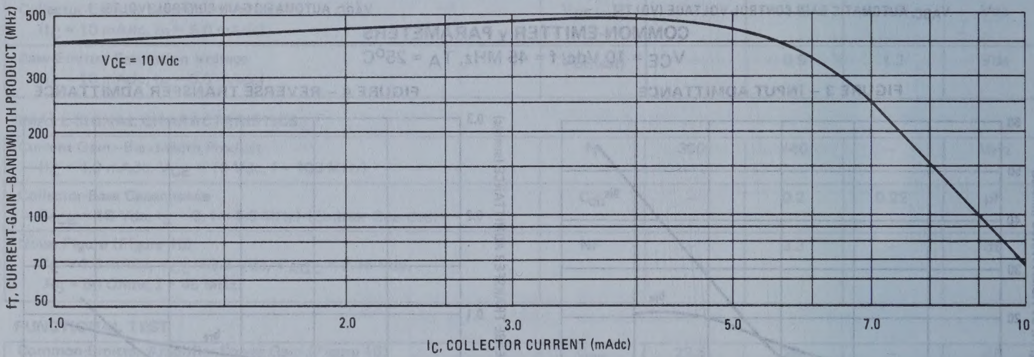
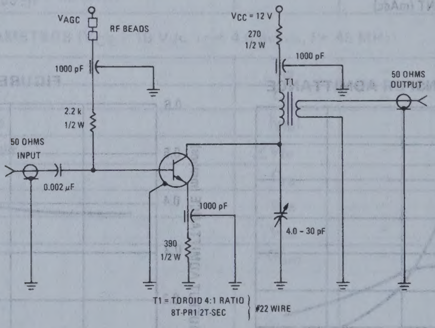


FIGURE 10 – 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)


V_{AGC}
RF BEADS
1000 pF
2.2 k
1/2 W
50 OHMS
INPUT
0.002 μF
1000 pF
390
1/2 W
V_{CC} = 12 V
270
1/2 W
1000 pF
T1
50 OHMS
OUTPUT
4.0 – 30 pF
T1 = TOROID 4:1 RATIO
8T-PRI 2T-SEC
#22 WIRE

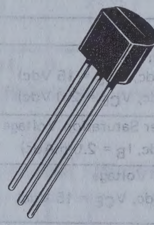
MPS-H34 (SILICON)

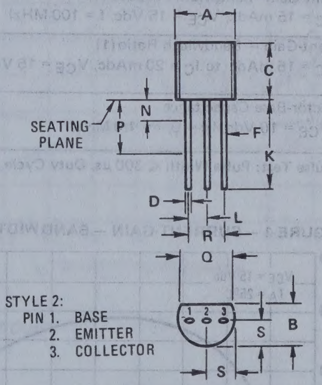
NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for third-stage video IF applications in television receivers.

- High Collector-Emitter Breakdown Voltage – BV_{CEO} = 45 Vdc (Min)
- High Collector-Base Breakdown Voltage – BV_{CBO} = 45 Vdc (Min)
- Low Collector-Base Capacitance – C_{cb} = 0.32 pF (Max) @ V_{CB} = 10 Vdc
- Complete y-Parameter Curves @ 45 MHz

NPN SILICON IF TRANSISTOR





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 50	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{o}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	45	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 7.0 mAdc, V_{CE} = 15 Vdc) (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	 40 15	 – –	 – –	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 7.0 mAdc, V_{CE} = 15 Vdc)	$V_{BE(on)}$	–	–	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 15 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	500	720	–	MHz
Current-Gain — Bandwidth Ratio (1) (I_C = 15 mAdc to I_C = 20 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	$\frac{f_{T15}}{f_{T20}}$	–	–	1.6	–
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.25	0.32	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – CURRENT-GAIN – BANDWIDTH PRODUCT

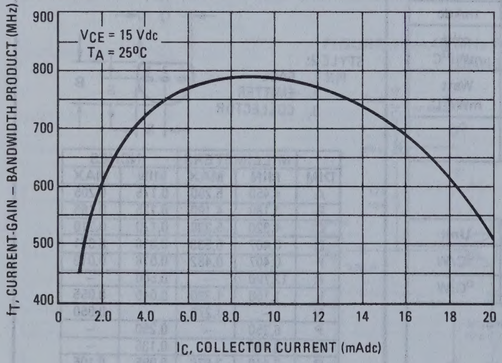
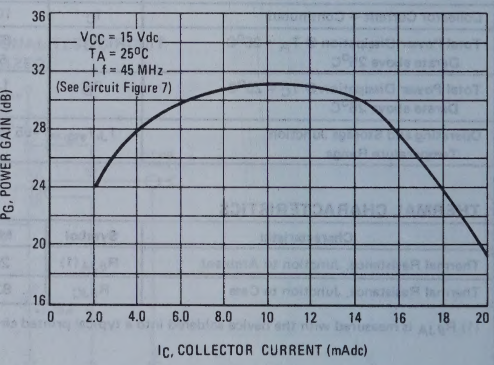


FIGURE 2 – POWER GAIN



COMMON-EMITTER y PARAMETERS

(f = 45 MHz, V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 — INPUT ADMITTANCE

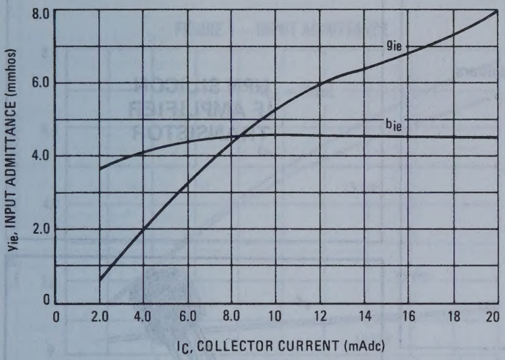


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

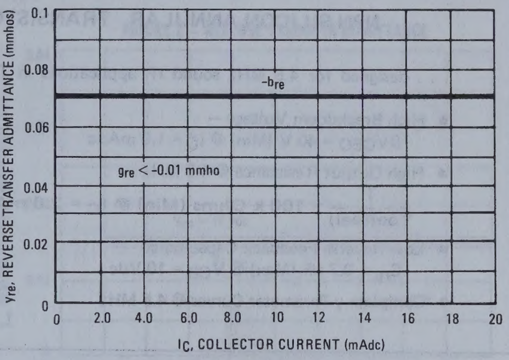


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

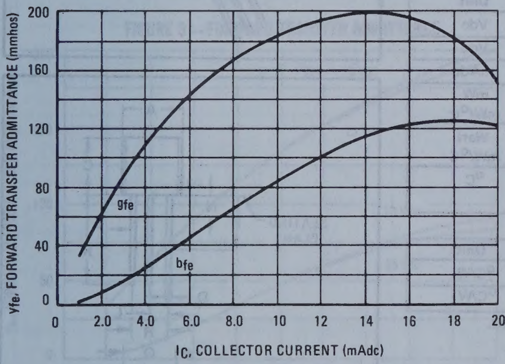


FIGURE 6 — OUTPUT ADMITTANCE

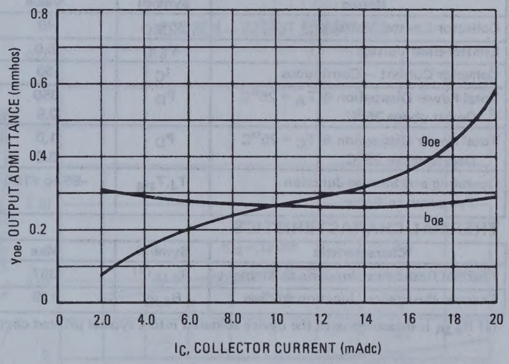
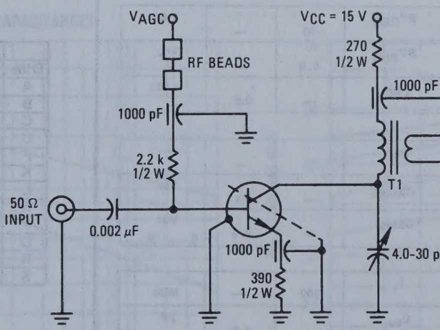


FIGURE 7 — 45 MHz FUNCTIONAL TEST CIRCUIT
(UNNEUTRALIZED)


VAGC
RF BEADS
1000 pF
2.2 k
1/2 W
50 Ω
INPUT
0.002 μF
1000 pF
390
1/2 W
VCC = 15 V
270
1/2 W
1000 pF
50 Ω
OUTPUT
T1
4.0-30 pF

T1 = TOROID 4:1 RATIO
8T-PR1, 2T-SEC } #22 WIRE

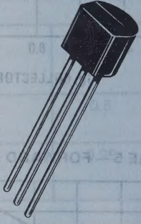
MPS-H37 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for 4.5 MHz sound IF applications in TV receivers.

- High Breakdown Voltage — $BV_{CEO} = 40$ V (Min) @ $I_C = 1.0$ mAdc
- High Output Resistance @ 4.5 MHz — $\frac{1}{Yoe(real)} = 100$ k Ohms (Min) @ $I_C = 2.0$ mAdc
- Low Reverse Feedback Capacitance — $C_{re} = 0.7$ pF (Max) @ $V_{CB} = 10$ Vdc
- Complete y-Parameter Curves @ 4.5 MHz

NPN SILICON
IF AMPLIFIER
TRANSISTOR



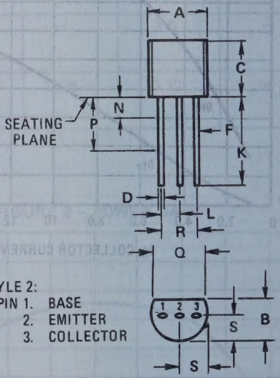
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_E = 0$)	BV_{CEO}	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 35$ Vdc, $I_E = 0$)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc)	$V_{BE(on)}$	—	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	f_T	300	—	MHz
Common-Emitter Reverse Transfer Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$)	C_{re}	—	0.7	pF
Real Part of Output Resistance ($I_C = 2.0$ mAdc, $V_{CE} = 10$ Vdc, f = 4.5 MHz)	$\frac{1}{Yoe(real)}$	100	—	k ohms

COMMON-EMITTER y PARAMETERS

f = 4.5 MHz, T_A = 25°C

FIGURE 1 — INPUT ADMITTANCE

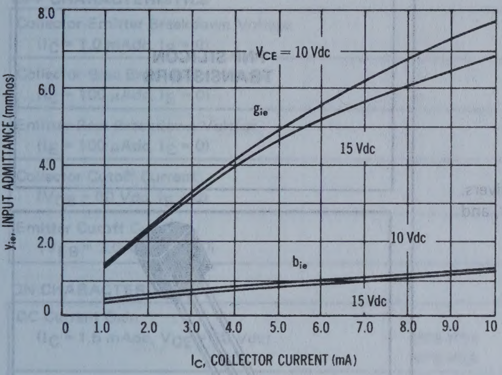


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

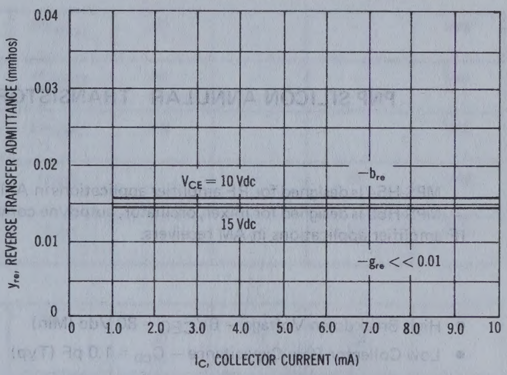


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

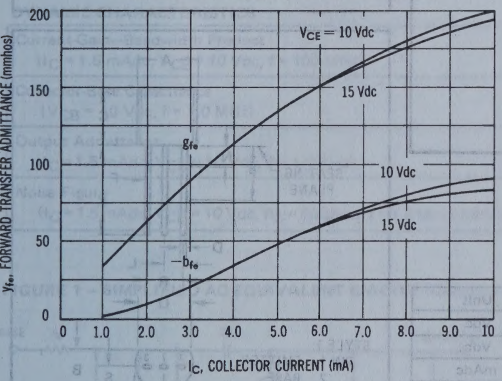


FIGURE 4 — OUTPUT ADMITTANCE

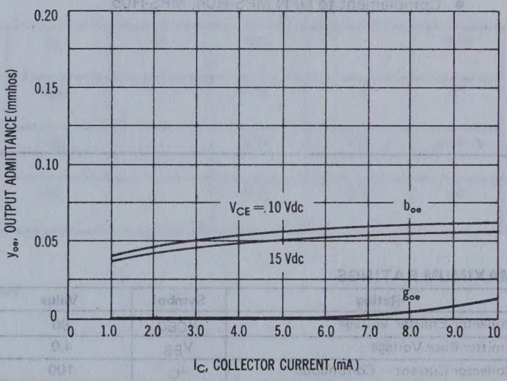


FIGURE 5 — CAPACITANCES

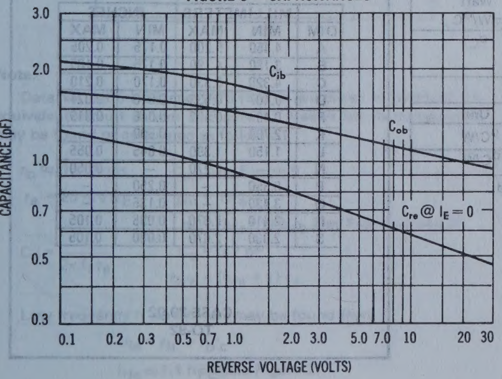
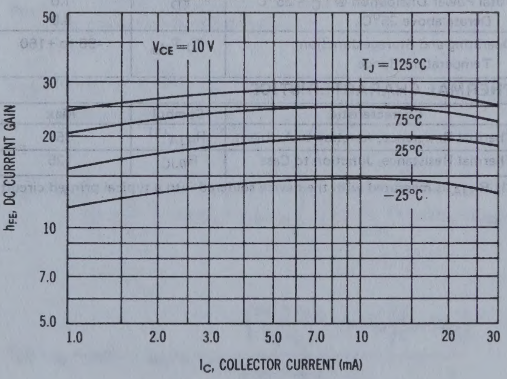


FIGURE 6 — DC CURRENT GAIN



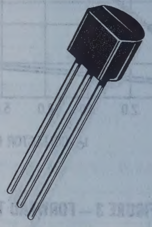
MPS-H54 (SILICON)
MPS-H55

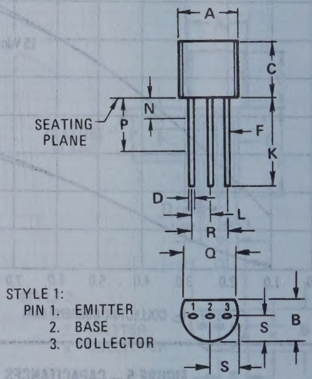
PNP SILICON TRANSISTORS

PNP SILICON ANNULAR TRANSISTORS

. . . MPS-H54 is designed for RF amplifier applications in AM receivers.
. . . MPS-H55 is designed for mixer, oscillator, autodyne converter, and IF amplifier applications in AM receivers.

- High Breakdown Voltage – BV_{CEO} = 80 Vdc (Min)
- Low Collector-Base Capacitance – C_{cb} = 1.0 pF (Typ)
- Low Output Admittance – h_{oe} = 15 μmhos (Max)
- Low Noise Figure – NF = 2.0 dB (Max) – MPS-H54
- Complement to NPN MPS-H04, MPS-H05





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

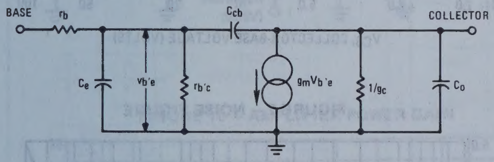
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	80	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc) MPS-H54 MPS-H55	h_{FE}	30 30	70 70	120 150	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.16	0.25	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	80	185	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	–	1.0	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	6.6	15	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz) MPS-H54	NF	–	1.5	2.0	dB

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-H04 and MPS-H05 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

$r_b' \approx 15$ Ohms

$r_e = 26\ \text{mV}/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

C_{cb}, See Figure 5

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\, h_{ob}$ (See Figures 3 and 6)

$C_o = 0.2$ pF

$r_{b'c} = (h_{fe} + 1)\, r_e$

Low frequency h parameters may be found from:

$h_{ie} = r_b' + r_{b'c}$

$h_{fe} \approx 1.1\, h_{FE}$ (See Figure 2)

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\, h_{ob}$

y Parameters may be determined from the following calculations:

$$y_{11} = \frac{1 + j\omega (C_e + C_{cb})\, r_{b'c}}{(r_b' + r_{b'c}) + j\omega (C_e + C_{cb})\, r_b' r_{b'c}}$$

$$y_{12} = \frac{j\omega C_{cb}}{j\omega (C_{cb} + C_e)\, r_b' + \dfrac{r_b' + r_{b'c}}{r_{b'c}}}$$

$$y_{21} = g_m \left(\frac{1}{\left(1 + \dfrac{r_b'}{r_{b'c}}\right) + j\omega (C_e + C_{cb})\, r_b'} \right) - \frac{j\omega C_{cb}}{\left(1 + \dfrac{r_b'}{r_{b'c}}\right) + j\omega (C_e + C_{cb})\, r_b'}$$

$$y_{22} = g_c + jwCo - g_m r_b' y_{12} + \frac{\left(\dfrac{r_b' + r_{b'c}}{r_b' r_{b'c}} + j\omega C_e\right)\left(j\omega C_{cb}\right)}{\left(\dfrac{r_b' + r_{b'c}}{r_b' r_{b'c}} + j\omega\ (C_e + C_{cb})\right)}$$

ELECTRICAL CHARACTERISTICS (V_{CE} = 10 V, T_A = 25°C unless otherwise noted)

FIGURE 2 – NORMALIZED DC CURRENT GAIN

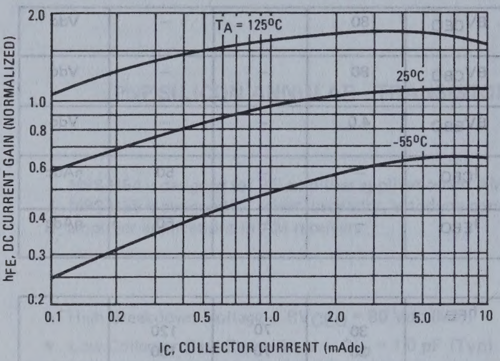


FIGURE 3 – "ON" VOLTAGES

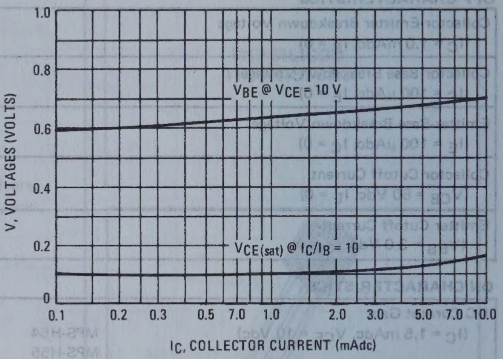


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

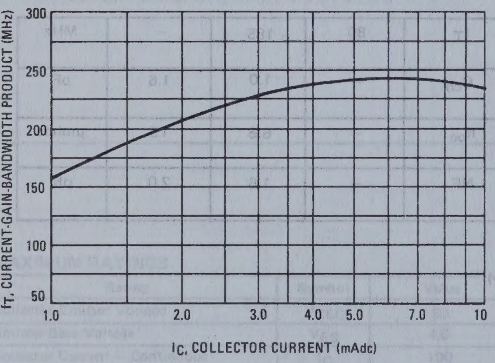


FIGURE 5 – COLLECTOR-BASE CAPACITANCE

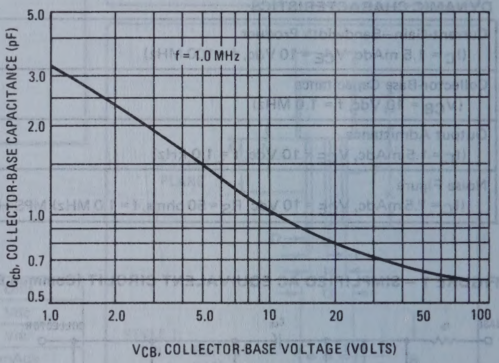


FIGURE 6 – OUTPUT ADMITTANCE

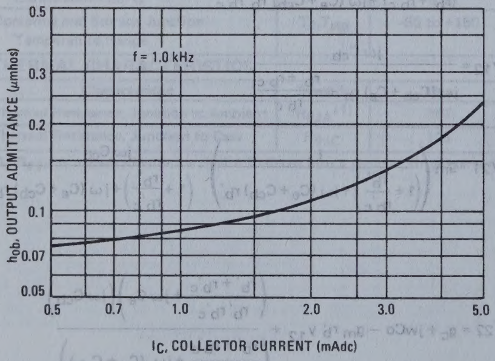
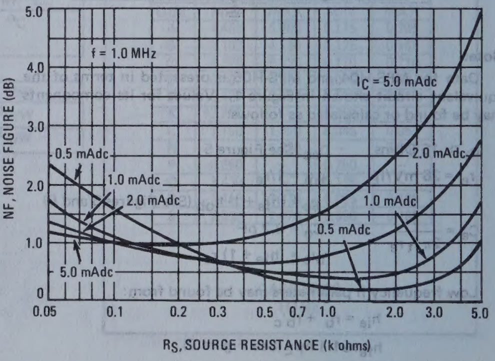


FIGURE 7 – NOISE FIGURE



AM RADIO DESIGN INFORMATION

FIGURE 8 – 1.0 MHz AMPLIFIER TEST CIRCUIT

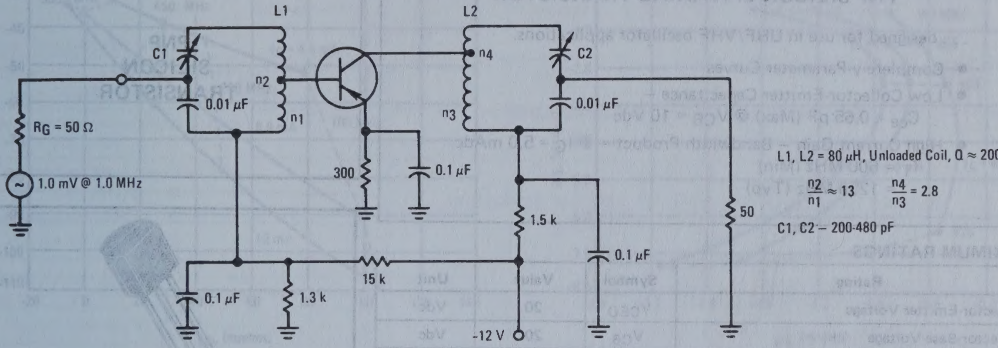

L1
L2
C1
n2
n4
C2
0.01 μF
n1
n3
0.01 μF
RG = 50 Ω
300
0.1 μF
1.0 mV @ 1.0 MHz
1.5 k
50
0.1 μF
15 k
0.1 μF
1.3 k
-12 V
L1, L2 = 80 μH, Unloaded Coil, Q ≈ 200
n2/n1 ≈ 13
n4/n3 = 2.8
C1, C2 – 200-480 pF

FIGURE 9 – 1.0 MHz MIXER TEST CIRCUIT

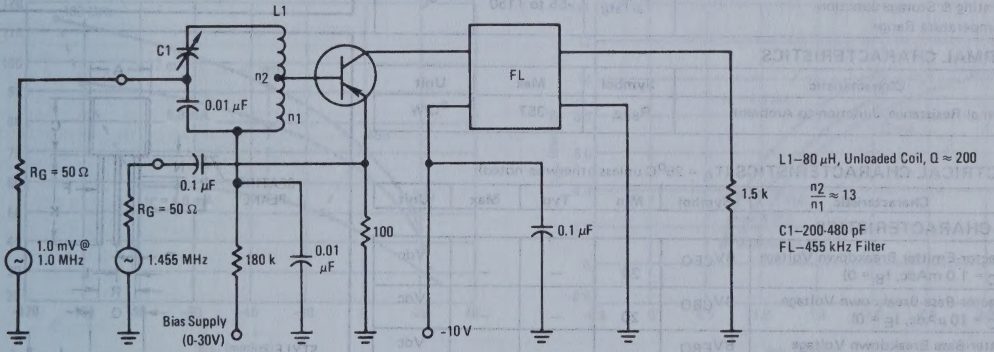

L1
C1
n2
0.01 μF
n1
FL
RG = 50 Ω
0.1 μF
RG = 50 Ω
1.5 k
100
0.1 μF
1.0 mV @ 1.0 MHz
1.455 MHz
180 k
0.01 μF
Bias Supply (0-30V)
-10 V
L1–80 μH, Unloaded Coil, Q ≈ 200
n2/n1 ≈ 13
C1–200-480 pF
FL–455 kHz Filter

FIGURE 10 – AMPLIFIER POWER GAIN

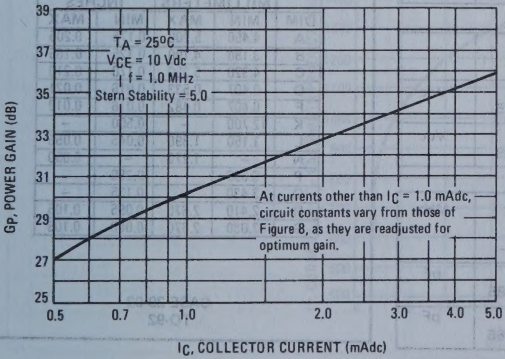
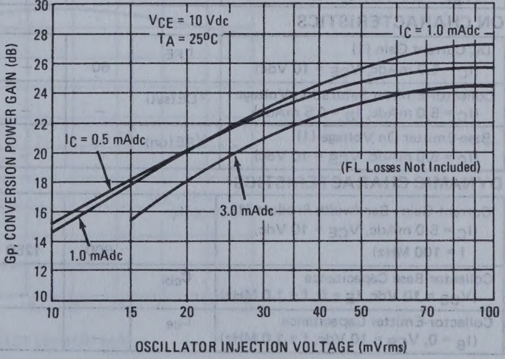


FIGURE 11 – CONVERSION POWER GAIN



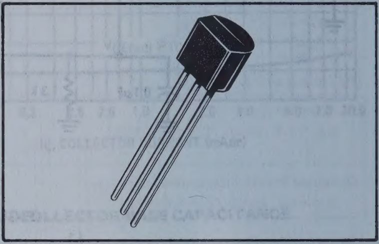
MPS-H81 (SILICON)

PNP SILICON EPITAXIAL TRANSISTOR

. . . designed for use in UHF/VHF oscillator applications.

- Complete y-Parameter Curves
- Low Collector-Emitter Capacitance —
  C_{ce} = 0.65 pF (Max) @ V_{CB} = 10 Vdc
- High Current Gain — Bandwidth Product — @ I_C = 5.0 mAdc
  f_T = 600 MHz (Min)
  = 1250 MHz (Typ)

PNP
SILICON
TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipaton @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

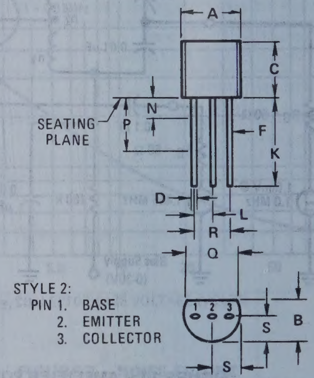
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	–	–	–
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter On Voltage (1) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1250	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	–	0.85	pF
Collector-Emitter Capacitance (I_B = 0, V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{ce}	–	–	0.65	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.



STYLE 2:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

TYPICAL COMMON-BASE y-PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 1 – INPUT ADMITTANCE

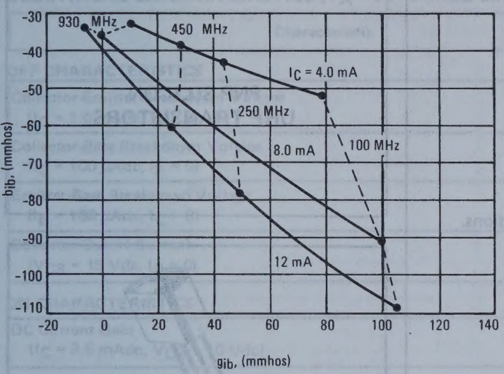


FIGURE 2 – REVERSE TRANSFER ADMITTANCE

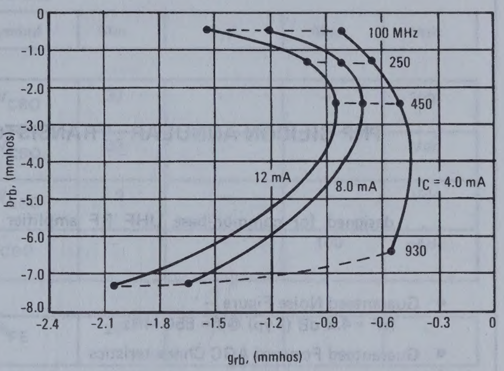


FIGURE 3 – FORWARD TRANSFER ADMITTANCE

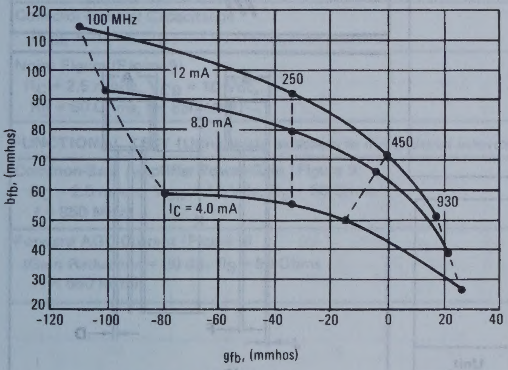


FIGURE 4 – OUTPUT ADMITTANCE

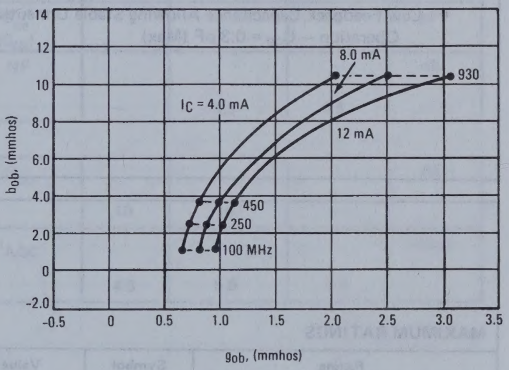
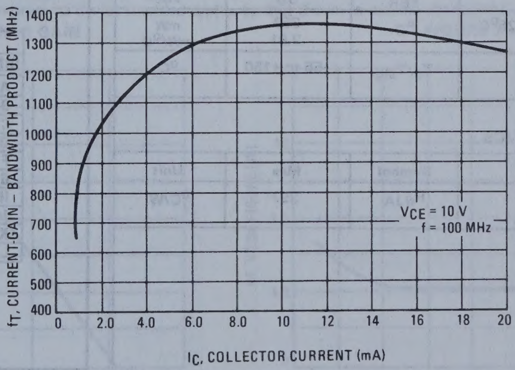


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT



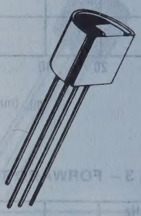
MPS-H83 (SILICON)

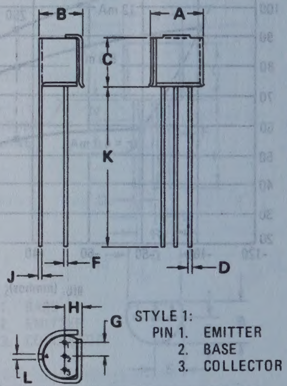
PNP SILICON ANNULAR TRANSISTORS

. . . designed for common-base UHF RF amplifier applications.

- Guaranteed Noise Figure –
  NF = 4.2 dB (Typ) @ f = 850 MHz
- Guaranteed Forward AGC Characteristics
- Complete y-Parameter Curves from 400 MHz to 900 MHz
- Guaranteed Power Gain –
  G_{pb} = 16 dB (Typ) @ f = 850 MHz
- Low Feedback Capacitance Allowing Stable Unneutralized Operation – C_{ce} = 0.3 pF (Max)

PNP SILICON
UHF TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.03	5.18	0.198	0.204
B	4.01	4.27	0.158	0.168
C	4.44	4.70	0.175	0.185
D	0.41	0.48	0.016	0.019
F	0.25	0.38	0.010	0.015
G	1.14	1.40	0.045	0.055
H	1.40	1.65	0.055	0.065
J	0.23	0.28	0.009	0.011
K	12.70	–	0.500	–
L	0.33	0.38	0.013	0.015

CASE 29A
PLASTIC TRANSISTOR AND UNATTACHED SHIELD SUPPLIED

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipaiton @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^{o}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.5 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	950	–	MHz
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)	C_{ce} (C_{rb})	–	–	0.3	pF
Noise Figure (Figure 9) (I_C = 2.5 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 850 MHz)	NF	–	4.2	6.5	dB
FUNCTIONAL TEST (Using shield as shown in dimensional information)					
Common-Base Amplifier Power-Gain (Figure 9) (I_C = 2.5 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms f = 850 MHz)	G_{pb}	10	16	–	dB
Forward AGC Current (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms f = 850 MHz)	I_{AGC}	4.5	5.6	7.5	mAdc

AGC CHARACTERISTICS

V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 850 MHz, Data from Figure 9 represents device shielded similar to that shown in outline dimensions.

FIGURE 1 — POWER GAIN

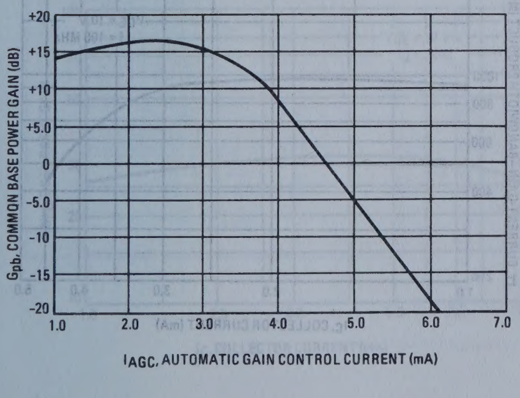
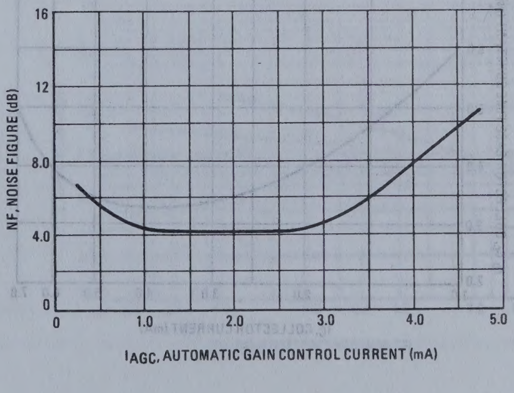


FIGURE 2 — NOISE FIGURE



COMMON-BASE y PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

FIGURE 3 – INPUT ADMITTANCE

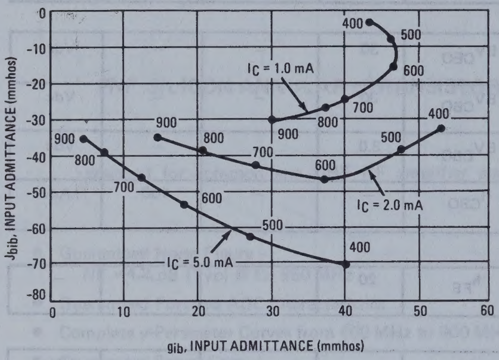


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

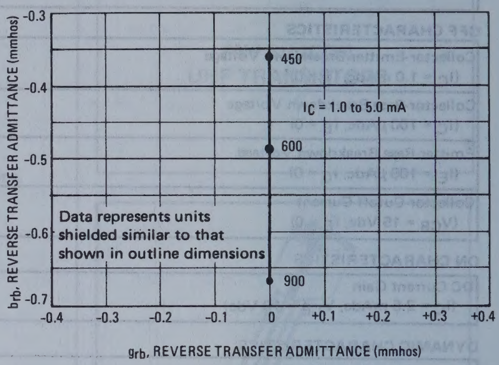


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

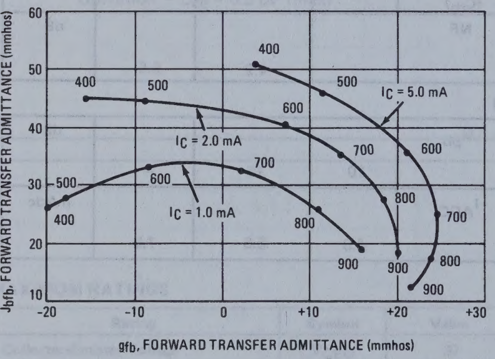


FIGURE 6 – OUTPUT ADMITTANCE

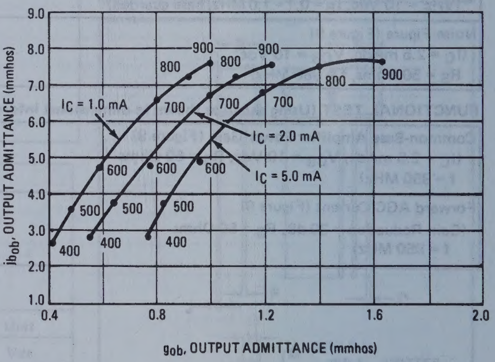


FIGURE 7 – COLLECTOR-BASE TIME CONSTANT

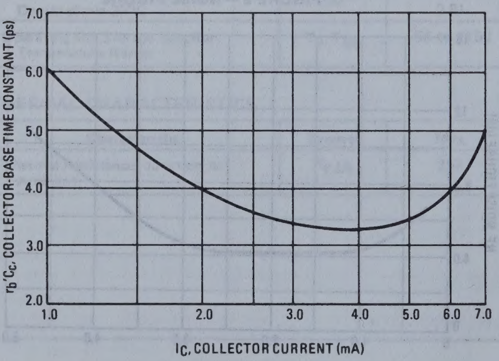


FIGURE 8 – CURRENT-GAIN–BANDWIDTH PRODUCT

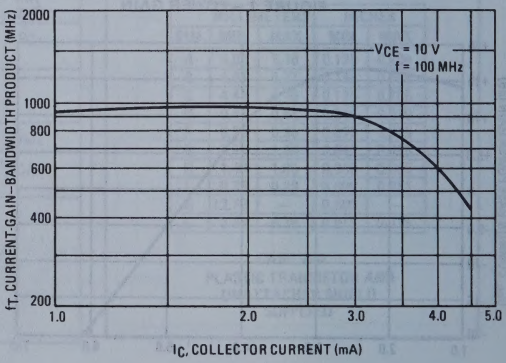
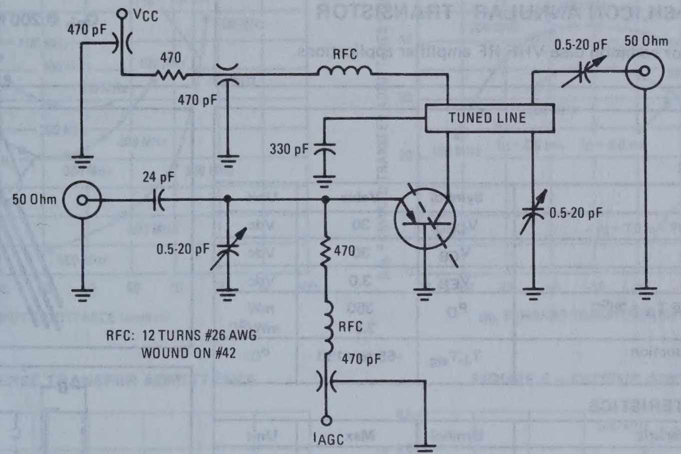


FIGURE 9 – 850 MHz COMMON BASE POWER GAIN AND NOISE FIGURE TEST FIXTURE


VCC
470 pF
470
470 pF
RFC
0.5-20 pF
50 Ohm
TUNED LINE
330 pF
24 pF
50 Ohm
0.5-20 pF
470
0.5-20 pF
RFC
470 pF
IAGC
RFC: 12 TURNS #26 AWG
WOUND ON #42

S FROM y PARAMETERS

$$S_{11} = \frac{(1 - y_{11})(1 + y_{22}) + y_{12} y_{21}}{D}$$

$$S_{22} = \frac{(1 + y_{11})(1 - y_{22}) + y_{21} y_{12}}{D}$$

$$S_{12} = \frac{-2 y_{12}}{D}$$

$$S_{21} = \frac{-2 y_{21}}{D}$$

Where $D = (1 + y_{11})(1 + y_{22}) - (y_{12} y_{21})$

In converting from y to S parameters, the y parameters must first be multiplied by Z_0, and then substituted in the equations for conversion to S parameters.

FIGURE 10 – DC CURRENT GAIN

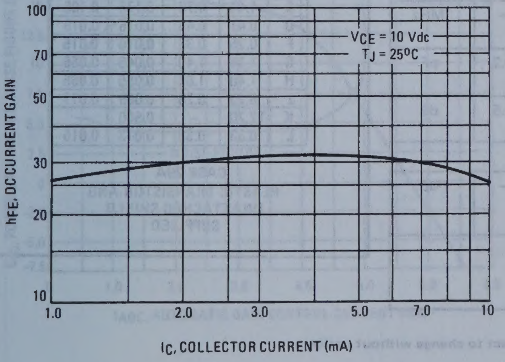
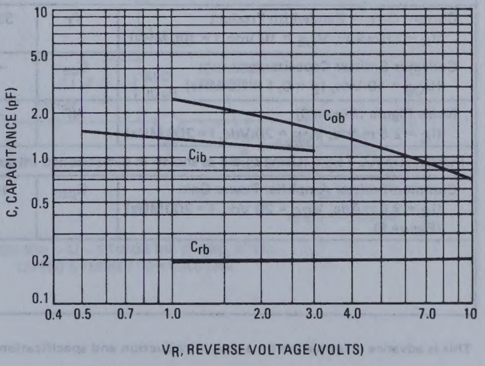


FIGURE 11 – CAPACITANCES



MPS-H85 (SILICON)

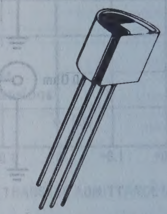
Advance Information

PNP SILICON ANNULAR TRANSISTOR

. . . designed for common base VHF RF amplifier applications.

PNP SILICON
VHF TRANSISTOR

G_{pb} @ 200 MHz > 14 dB



MAXIMUM RATINGS

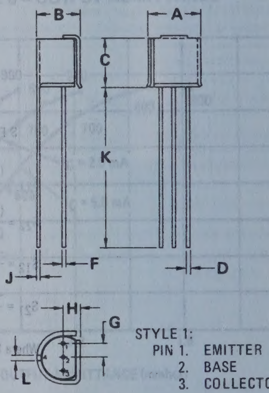
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted).

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.5 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	–	–
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	–	MHz
Collector-Emitter Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ce}	–	0.2	pF
Noise Figure (Figure 6) (I_C = 2.5 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	NF	–	6.5	dB
FUNCTIONAL TEST (Using shield as shown in dimensioned information).				
Common-Emitter Amplifier Power Gain (I_C = 2.5 mAdc, V_{CC} = 20 Vdc, f = 200 MHz) (Figure 6)	G_{pb}	14	–	dB



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.03	5.18	0.198	0.204
B	4.01	4.27	0.158	0.168
C	4.44	4.70	0.175	0.185
D	0.41	0.48	0.016	0.019
F	0.25	0.38	0.010	0.015
G	1.14	1.40	0.045	0.055
H	1.40	1.65	0.055	0.065
J	0.23	0.28	0.009	0.011
K	12.70	–	0.500	–
L	0.33	0.38	0.013	0.015

CASE 29A
PLASTIC TRANSISTOR AND
UNATTACHED SHIELD
SUPPLIED

This is advance information on a new introduction and specifications are subject to change without notice.

COMMON BASE y PARAMETERS

(V_{CB} = 10 Vdc, T_A = 25°C, Frequency Points in MHz)

Data represents units shielded similar to that shown in outline dimensions.

FIGURE 1 – INPUT ADMITTANCE

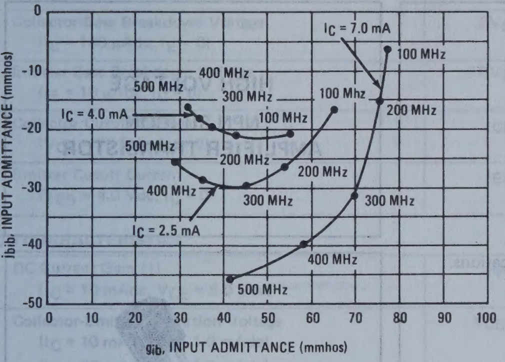


FIGURE 2 – FORWARD TRANSFER ADMITTANCE

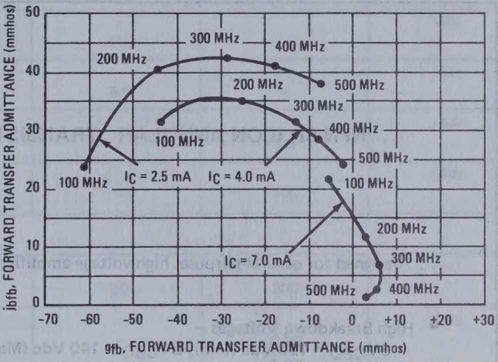


FIGURE 3 – REVERSE TRANSFER ADMITTANCE

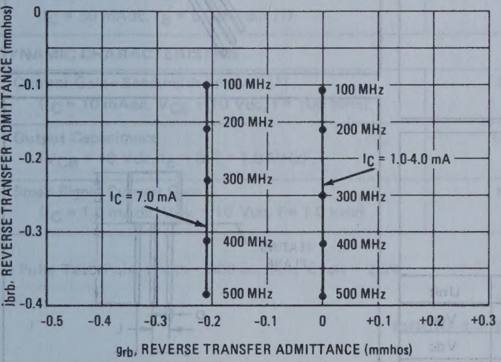
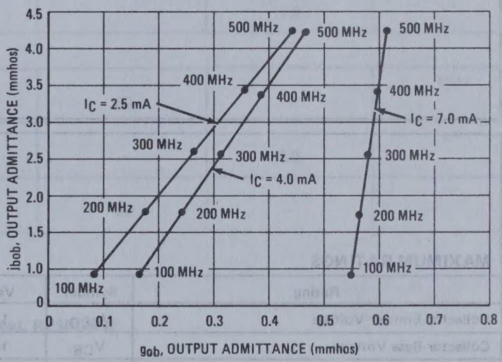


FIGURE 4 – OUTPUT ADMITTANCE



AGC CHARACTERISTICS

FIGURE 5 – POWER GAIN AND NOISE FIGURE

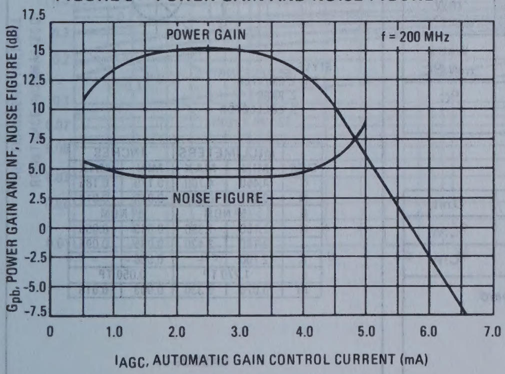
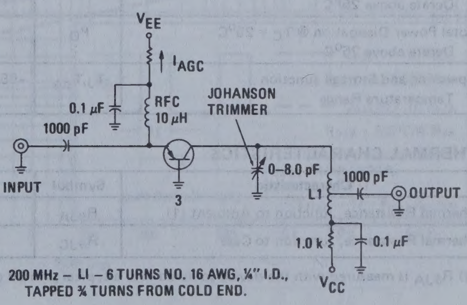


FIGURE 6 – AGC TEST CIRCUIT



V_{EE}
I_{AGC}
0.1 µF
RFC
10 µH
JOHANSON
TRIMMER
1000 pF
INPUT
3
0–8.0 pF
1000 pF
L1
OUTPUT
1.0 k
0.1 µF
V_{CC}

200 MHz – LI – 6 TURNS NO. 16 AWG, ¼" I.D., TAPPED ¾ TURNS FROM COLD END.

MPS-K20, MPS-K21, MPS-K22 (SILICON)

For Specifications, See MPS-A20 Data.

MPS-K70, MPS-K71, MPS-K72 (SILICON)

For Specifications, See MPS-A70 Data.

MPS-L01 (SILICON)

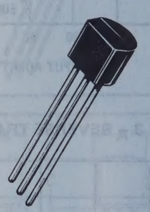
NPN SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier applications.

- High Breakdown Voltages —
  BV_{CEO} = 120 Vdc (Min), BV_{CBO} = 140 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.30 V (Max) @ I_C = 50 mA

HIGH VOLTAGE

NPN SILICON
AMPLIFIER TRANSISTOR



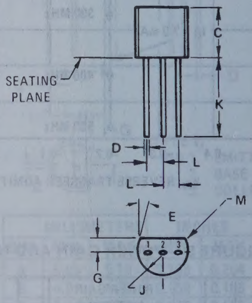
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	150	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	625 5.0	mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 12	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1)	$R_{\theta JA}$	200	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
C	4.450	4.700	0.175	0.185
D	0.407	0.482	0.016	0.019
E	5^0 NOM		5^0 NOM	
G	1.150	1.390	0.045	0.055
J	2.160	2.420	0.085	0.095
K	12.700	–	0.500	–
L	1.270 TP		0.050 TP	
M	0.076	0.330	0.003	0.013

CASE 29-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	120	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	– –	0.20 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (1)	$V_{BE(sat)}$	– –	1.2 1.4	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	–	–

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – THERMAL RESPONSE

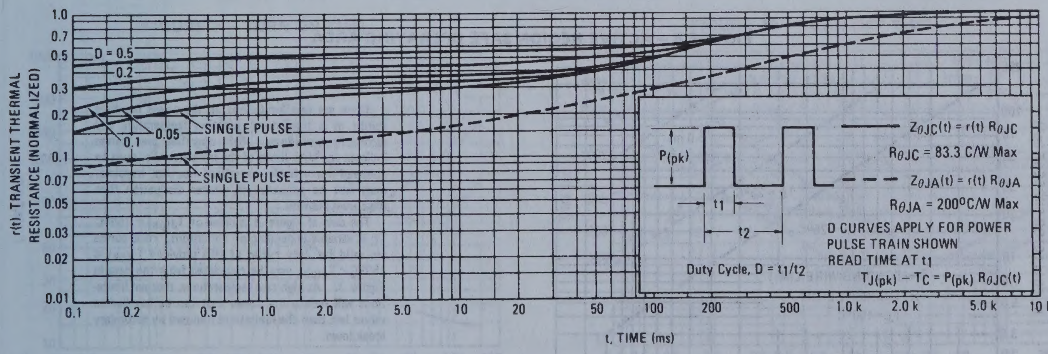


FIGURE 2 – DC CURRENT GAIN

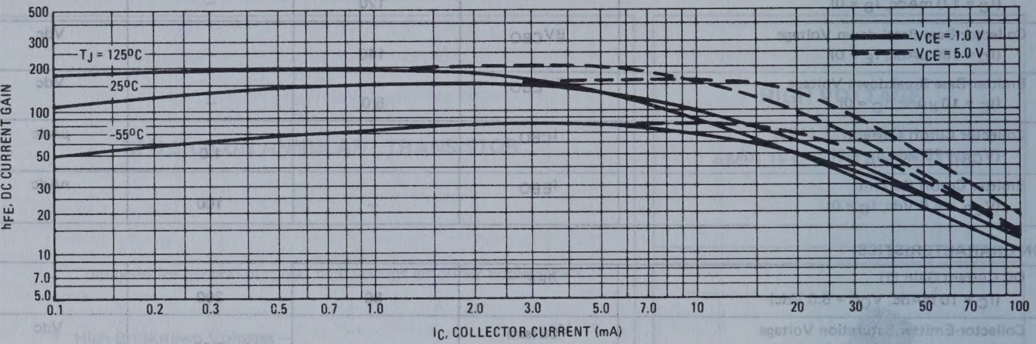


FIGURE 3 – COLLECTOR SATURATION REGION

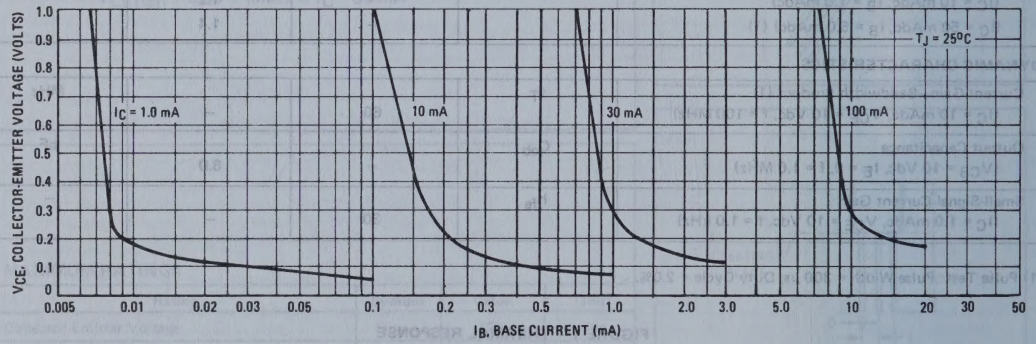
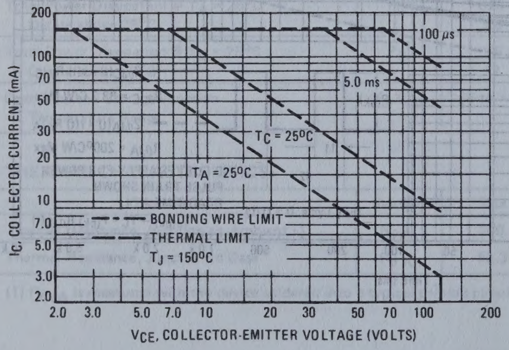


FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 150°C T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq$ 150°C. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 5 – "ON" VOLTAGES

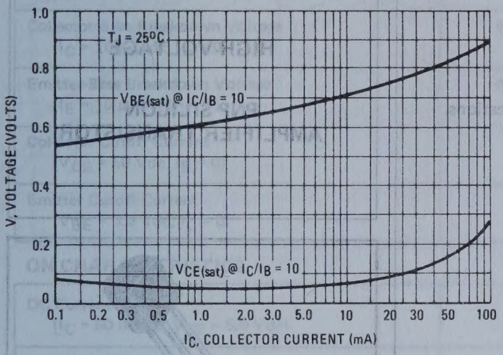


FIGURE 6 – TEMPERATURE COEFFICIENTS

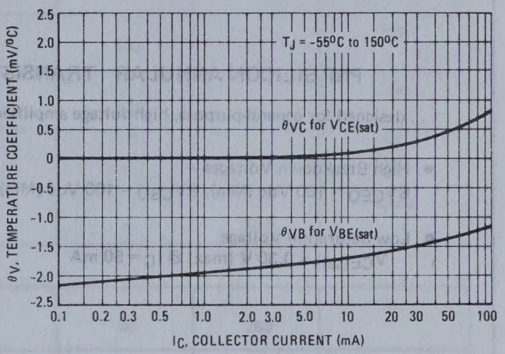
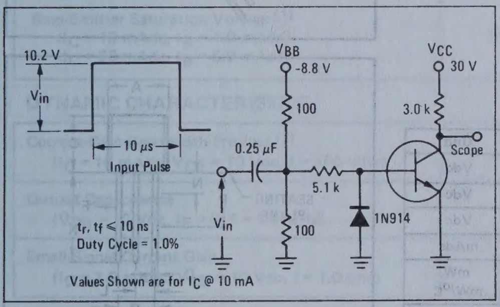


FIGURE 7 – SWITCHING TIME TEST CIRCUIT



10.2 V
V_in
10 μs
Input Pulse
t_r, t_f ≤ 10 ns
Duty Cycle = 1.0%
V_BB
-8.8 V
100
0.25 μF
5.1 k
V_in
100
1N914
V_CC
30 V
3.0 k
Scope
Values Shown are for I_C @ 10 mA

FIGURE 8 – CAPACITANCES

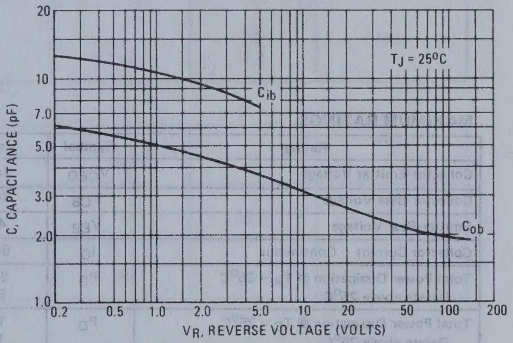


FIGURE 9 – TURN-ON TIME

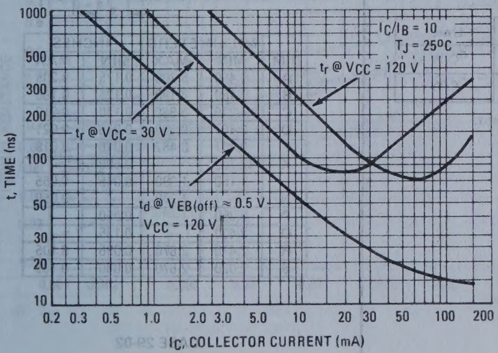
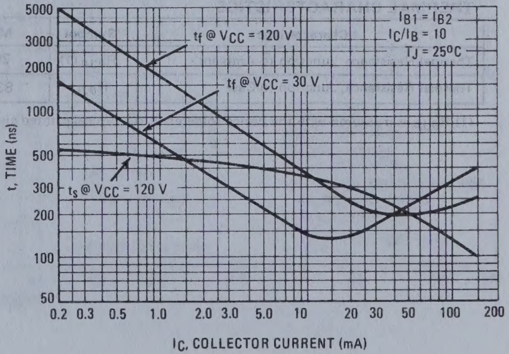


FIGURE 10 – TURN-OFF TIME



MPS-L51 (SILICON)

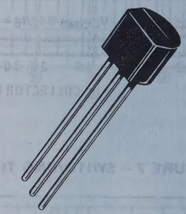
PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier applications.

- High Breakdown Voltages —
  BV_{CEO} = 100 Vdc (Min), BV_{CBO} = 100 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.30 V (max) @ I_C = 50 mA

HIGH VOLTAGE

PNP SILICON AMPLIFIER TRANSISTOR



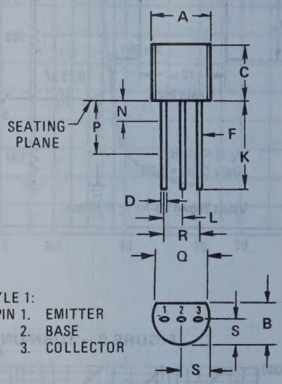
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	40	250	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	0.25 0.30	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	1.2 1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	–	–

(1) Pulse Test: Pulse Test = 300 μs. Duty Cycle = 2.0%

FIGURE 1 – THERMAL RESPONSE

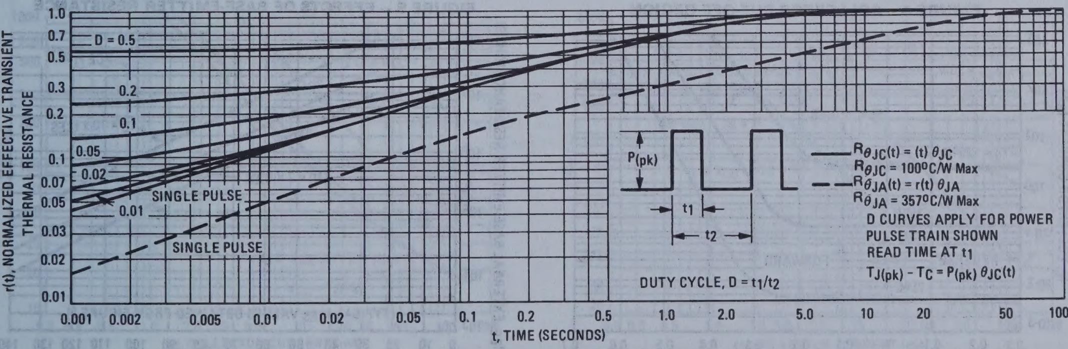


FIGURE 2 – DC CURRENT GAIN

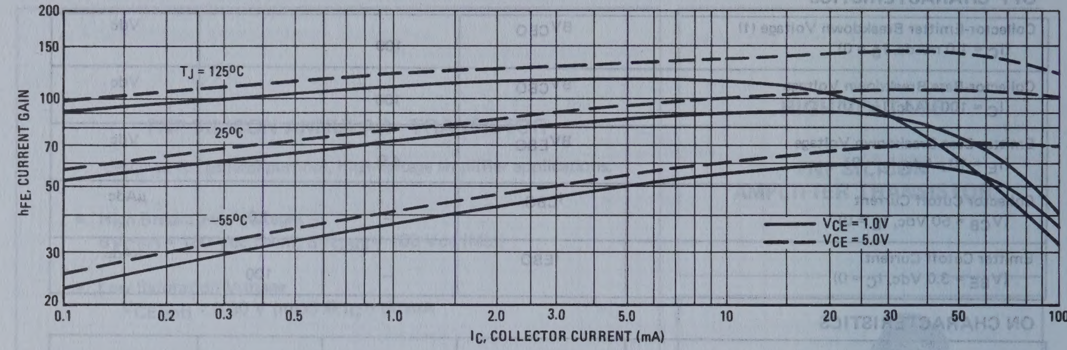


FIGURE 3 – COLLECTOR SATURATION REGION

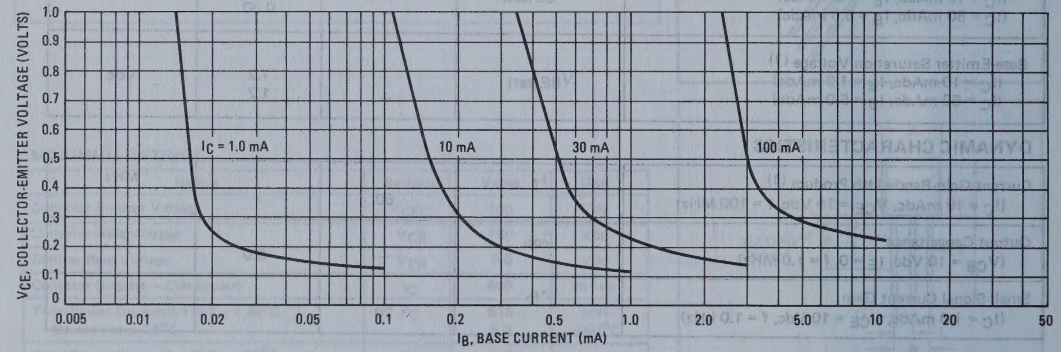
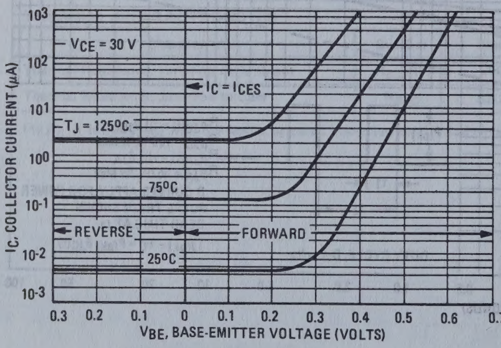


FIGURE 4 – COLLECTOR CUT-OFF REGION

FIGURE 5 – EFFECTS OF BASE-EMITTER RESISTANCE



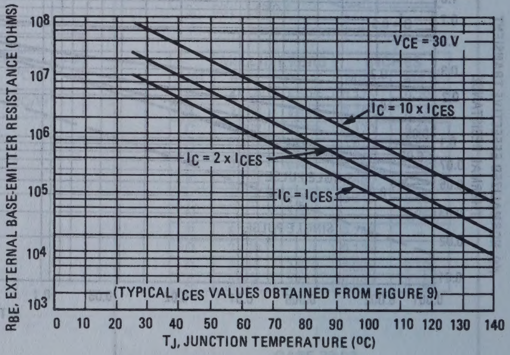


FIGURE 6 – "ON" VOLTAGES

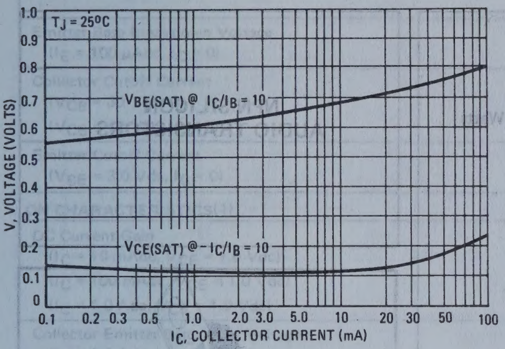


FIGURE 7 – TEMPERATURE COEFFICIENTS

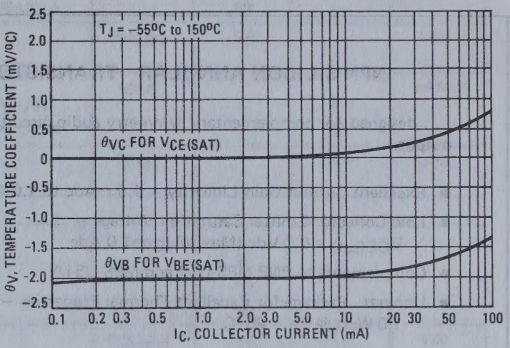
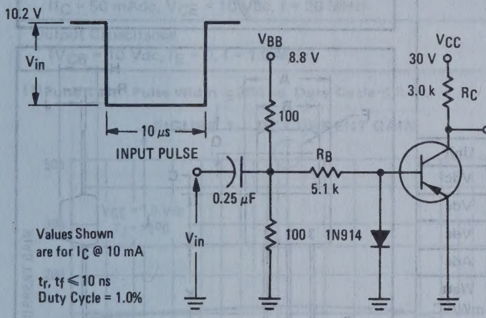


FIGURE 8 – SWITCHING TIME TEST CIRCUIT



10.2 V
Vin
10 μs
INPUT PULSE
VBB
8.8 V
100
0.25 μF
RB
5.1 k
100
1N914
Vin
VCC
30 V
3.0 k
RC
Vout
Values Shown are for IC @ 10 mA
tr, tf ≤ 10 ns
Duty Cycle = 1.0%

FIGURE 9 – CAPACITANCES

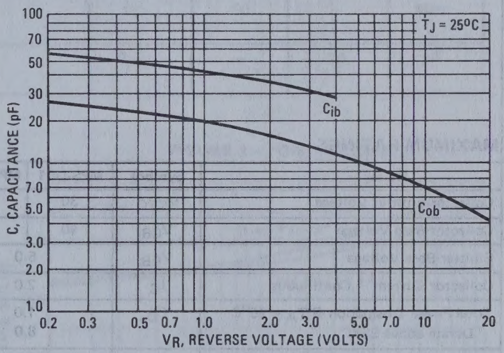


FIGURE 10 – TURN-ON TIME

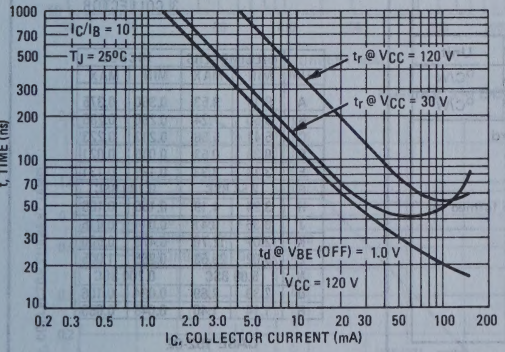
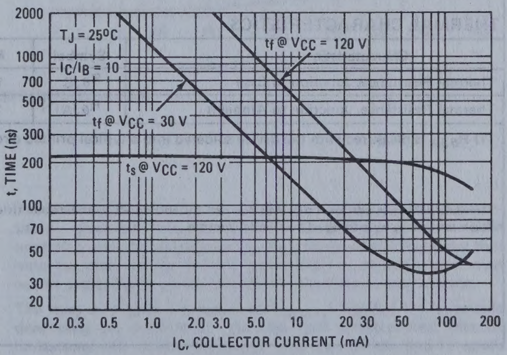


FIGURE 11 – TURN-OFF TIME



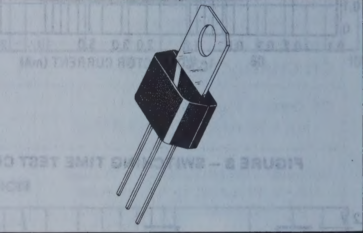
MPS-U01 (SILICON)
MPS-U01A

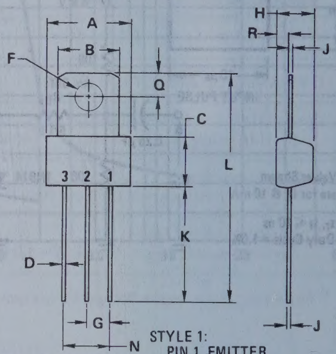
NPN SILICON ANNULAR TRANSISTORS

. . . designed for complementary symmetry audio circuits to 10 Watts output.

- Excellent Current Gain Linearity – 1.0 mAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)} = 0.5$ Vdc (Max) @ $I_C = 1.0$ Adc
- Complements to PNP MPS-U51 and MPS-U51A
- Uniwatt Package for Excellent Thermal Properties – 1.0 Watt @ $T_A = 25^oC$

NPN SILICON AUDIO TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

MAXIMUM RATINGS

Rating	Symbol	MPS-U01	MPS-U01A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	2.0		Adc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 8.0		Watt mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	10 80		Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	MPS-U01 MPS-U01A	BV_{CEO}	30 40	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS-U01 MPS-U01A	BV_{CBO}	40 50	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0)	MPS-U01 MPS-U01A	I_{CBO}	– –	0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		h_{FE}	55 60 50	– – –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	20	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

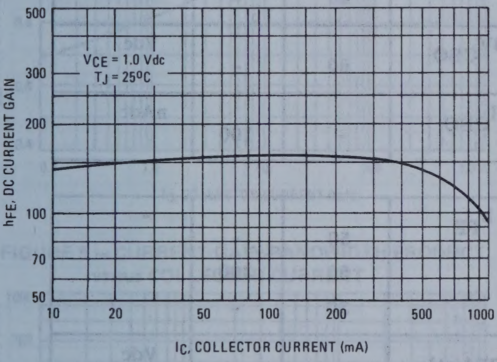


FIGURE 2 – "ON" VOLTAGES

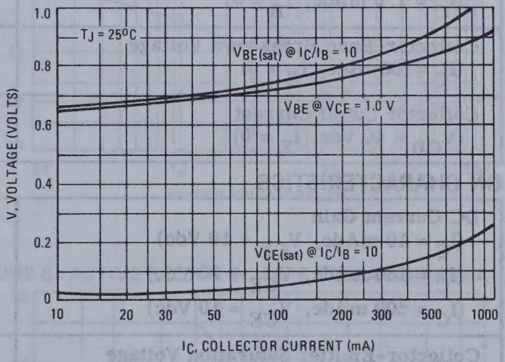
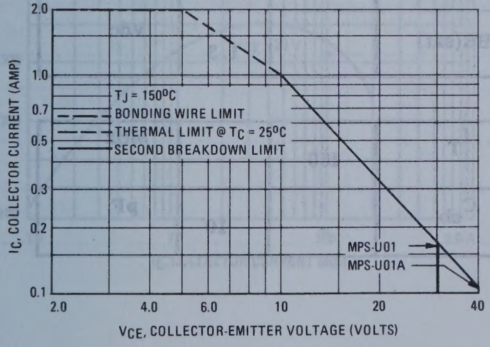


FIGURE 3 – DC SAFE OPERATING AREA

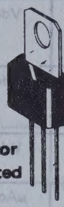


There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

MPS-U02 (SILICON)

NPN silicon annular amplifier transistors designed for general-purpose amplifier and driver applications. Complement to PNP MPS-U52.



CASE 152

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\mu$Adc, $I_E = 0$)	BV_{CBO}	60	-	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 50 50 30	 - 300 -	-
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	150	-	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	-	10	pF

FIGURE 1 – NORMALIZED DC CURRENT GAIN

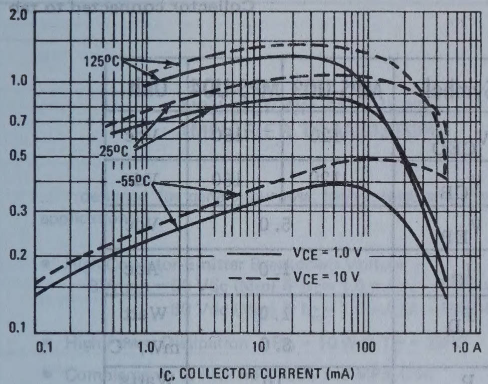


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

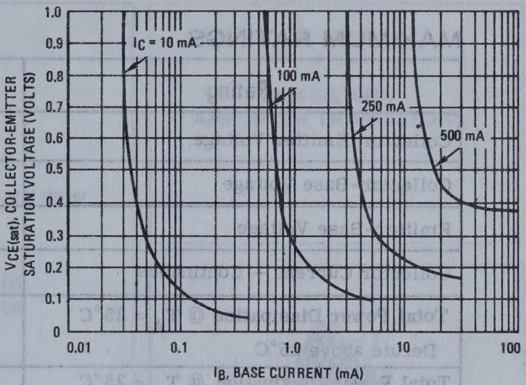


FIGURE 3 – BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

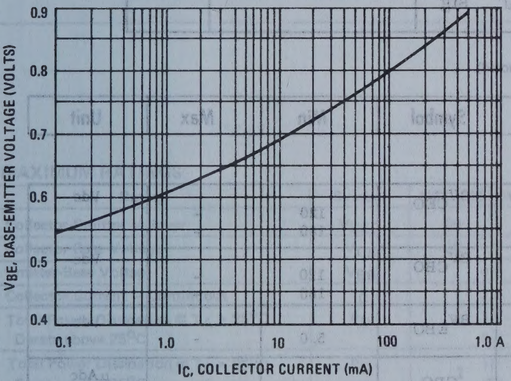


FIGURE 4 – CAPACITANCE versus VOLTAGE

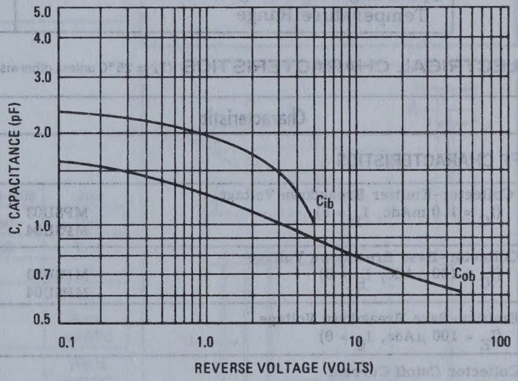


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

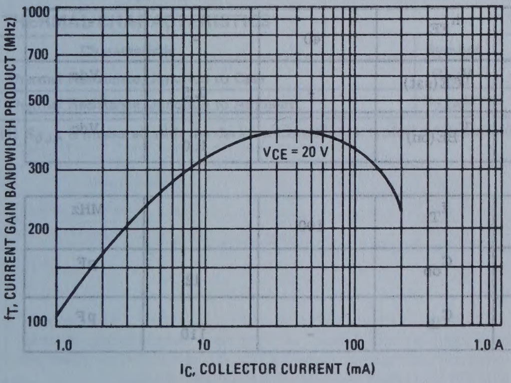
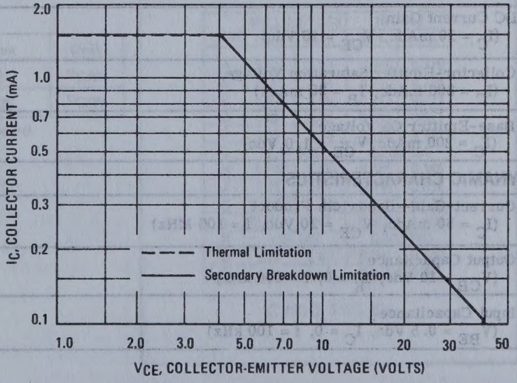
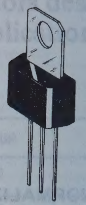


FIGURE 6 – ACTIVE REGION DC SAFE OPERATING AREA



MPS-U03 (SILICON)
MPS-U04

NPN silicon annular plastic transistors designed for video output circuits utilizing an emitter-follower driver and for horizontal driver applications in television receivers.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 152-02

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	MPS-U03	MPS-U04	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Collector-Base Voltage	V_{CB}	120	180	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	10 80		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	MPSU03 MPSU04	BV_{CEO}	120 180	- -	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	MPSU03 MPSU04	BV_{CBO}	120 180	- -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 100$ Vdc, $I_E = 0$) ($V_{CB} = 150$ Vdc, $I_E = 0$)	MPSU03 MPSU04	I_{CBO}	- -	0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		h_{FE}	40	-	-
Collector-Emitter Saturation Voltage ($I_C = 200$ mAdc, $I_B = 20$ mAdc)		$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter On Voltage ($I_C = 200$ mAdc, $V_{CE} = 1.0$ Vdc)		$V_{BE(on)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	100	-	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)		C_{ob}	-	12	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		C_{ib}	-	110	pF

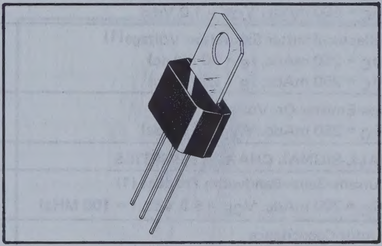
MPS-U05 (SILICON)
MPS-U06

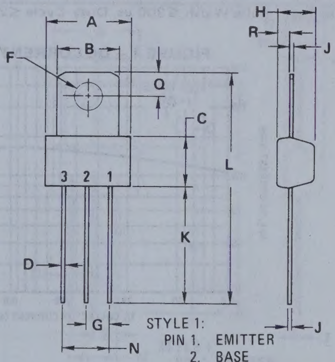
NPN SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc — MPS-U05
  80 Vdc (Min) @ I_C = 1.0 mAdc — MPS-U06
- High Power Dissipation — P_D = 10 W @ T_C = 25°C
- Complements to PNP MPS-U55 and MPS-U56

NPN SILICON AMPLIFIER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

MAXIMUM RATINGS

Rating	Symbol	MPS-U05	MPS-U06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-U05 MPS-U06	BV_{CEO}	60 80	– –	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	MPS-U05 MPS-U06	I_{CBO}	– –	– –	100 100	nAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	80 60 –	125 100 55	– – –	–
Collector-Emitter Saturation Voltage(1) (I_C = 250 mAdc, I_B = 10 mAdc) (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{CE(sat)}$	– –	0.18 0.1	0.4 –	Vdc
Base-Emitter On Voltage (1) (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.74	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	170	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	6.0	12	pF

(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – DC CURRENT GAIN

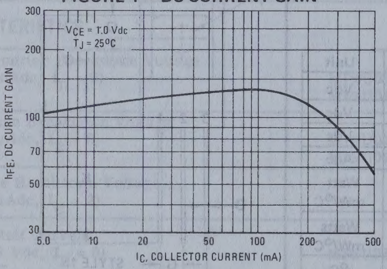


FIGURE 2 – "ON" VOLTAGES

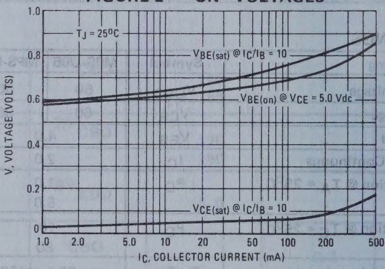


FIGURE 3 – DC SAFE OPERATING AREA

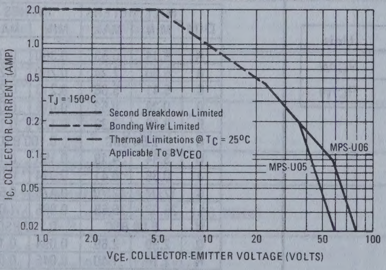
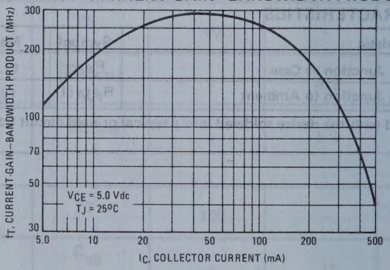


FIGURE 4 – CURRENT-GAIN—BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

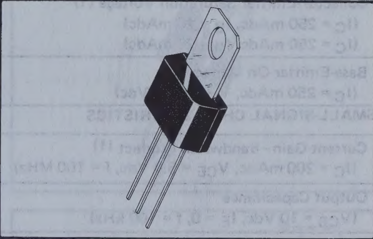
MPS-U07 (SILICON)

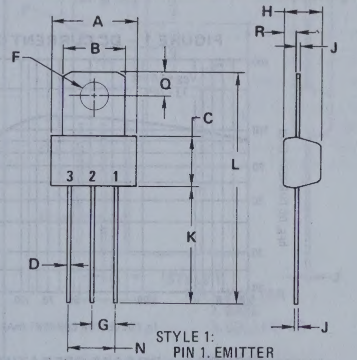
NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 100 Vdc (Min) @ I_C = 1.0 mAdc
- High Power Dissipation — P_D = 10 W @ T_C = 25°C
- Complement to PNP MPS-U57

NPN SILICON AMPLIFIER TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Power Dissipaton @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Power Dissipaton @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)	h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		60	110	–	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		30	65	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		–	33	–	
Collector-Emitter Saturation Voltage (1)	$V_{CE(sat)}$				Vdc
(I_C = 250 mAdc, I_B = 10 mAdc)		–	0.18	0.4	
(I_C = 250 mAdc, I_B = 25 mAdc)		–	0.1	–	
Base-Emitter On Voltage (1) (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.76	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	50	175	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	6.0	12	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

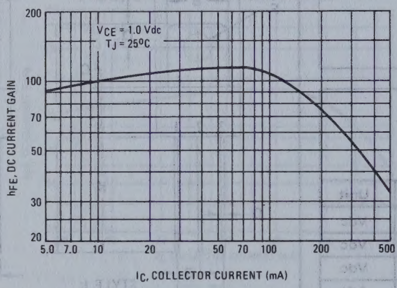


FIGURE 2 – "ON" VOLTAGES

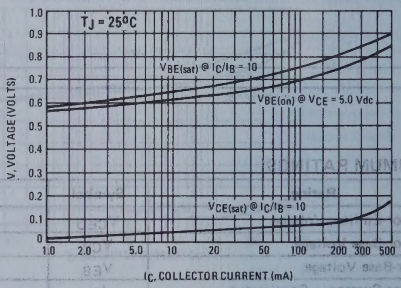


FIGURE 3 – DC SAFE OPERATING AREA

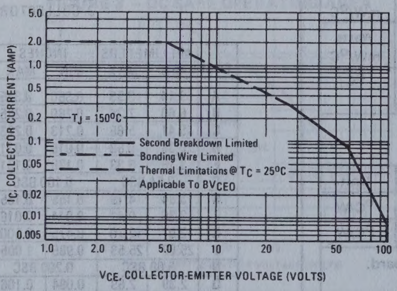
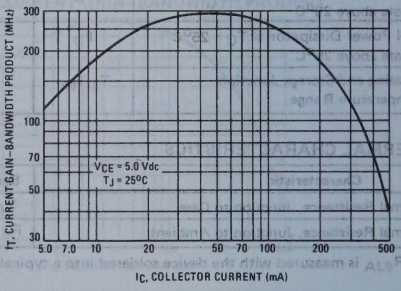


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

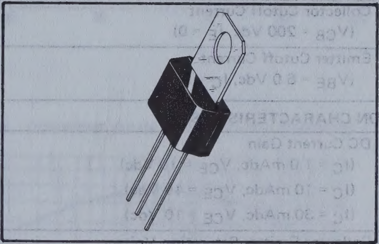
MPS-U10 (SILICON)

NPN SILICON
HIGH VOLTAGE
AMPLIFIER
TRANSISTOR

NPN SILICON ANNULAR TRANSISTOR

... designed for high-voltage video and luminance output stages in TV receivers.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 300 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.75 Vdc (Max) @ I_C = 30 mAdc
- Low Collector-Base Capacitance — C_{cb} = 3.0 pF (Max) @ V_{CB} = 20 Vdc



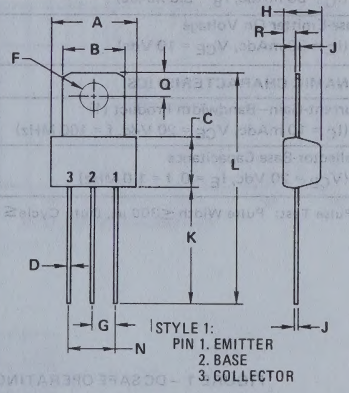
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

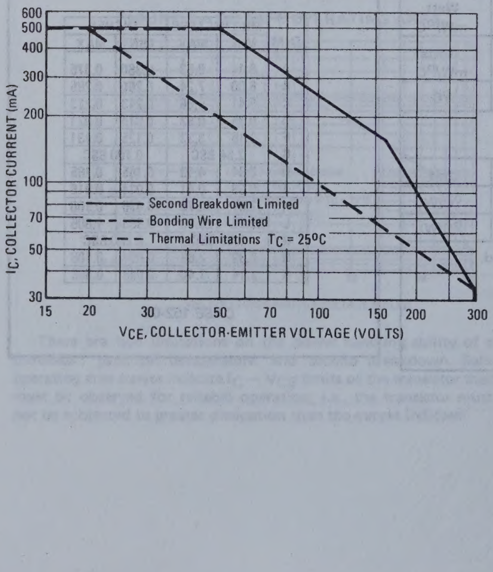
CASE 152-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	300	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	–	0.2	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 40 40	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	–	0.75	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	60	–	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	3.0	pF

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤ 2%.

FIGURE 1 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter second breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – DC CURRENT GAIN

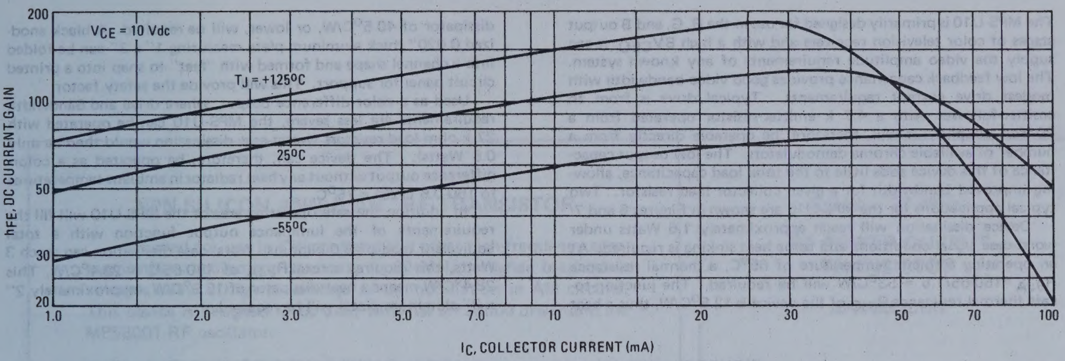


FIGURE 3 – CAPACITANCES

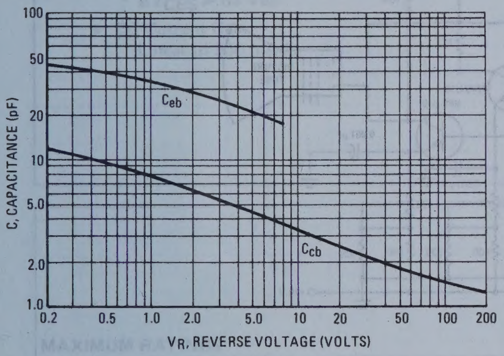


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

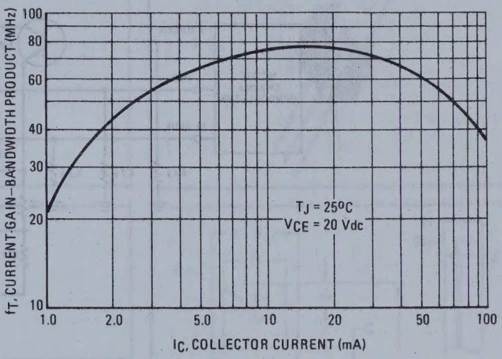
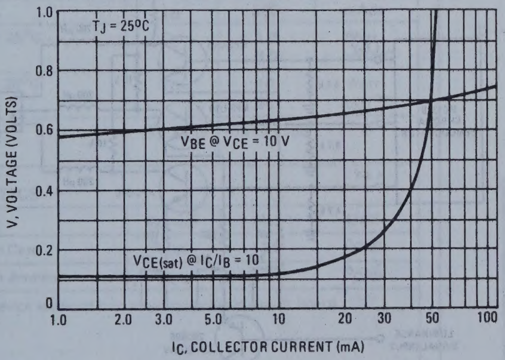


FIGURE 5 – "ON" VOLTAGES



APPLICATIONS INFORMATION

The MPS-U10 is primarily designed for use in the R, G, and B output stages of color television receivers and with a high BV_{CEO}, it can supply the video amplitude requirements of any known system. The low feedback capacitance provides good video bandwidth with modest drive current requirements. Typical drive is from an emitter-follower with a 4.7 k emitter-resistor operated from a 20-Volt supply. It will, therefore, be operable directly from a number of available chroma demodulators. The low output capacitance of this device adds little to the total load capacitance, allowing improved bandwidth for a given collector load resistor. Two typical applications for the MPS-U10 are shown in Figures 6 and 7.

Device dissipation will reach approximately 1.6 Watts under worst-case signal conditions and some heat sinking is required. At an operating ambient temperature of 65°C, a thermal resistance $R_{\theta JA}$ = 150-65/1.6 = 53°C/W will be required. The junction-to-case thermal resistance, $R_{\theta JC}$, of the device is 12.5°C/W, thus a heat dissipator of 40.5°C/W, or lower, will be required. A black anodized 0.020" thick aluminum plate measuring 1" x 2" can be folded into a channel shape and formed with "feet" to snap into a printed circuit panel for support. This will provide the safety factor.

Used as a color difference output, where drive and bandwidth requirements are less severe, the MPS-U10 can be operated with 27 k ohm load resistors (worst-case dissipation would then be only 0.6 Watts). The device can, therefore, be operated as a color-difference output without any heat radiator in ambient temperatures to 150-0.6 (125) = 75°C.

In addition the safe operating area of the MPS-U10 will fill the requirements of the luminance output function with a total equivalent load of 5.0 kilohms. Worst-case dissipation can reach 3 Watts, this requires a total $R_{\theta JA}$ of 150-65/3 = 28.4°C/W. This 28.4°C/W means a heat dissipator of 15.9°C/W, (approximately 2" x 3" aluminum plate) will be required.

FIGURE 6 – MPS-U10 AS RGB OUTPUT WITH RGB INPUT

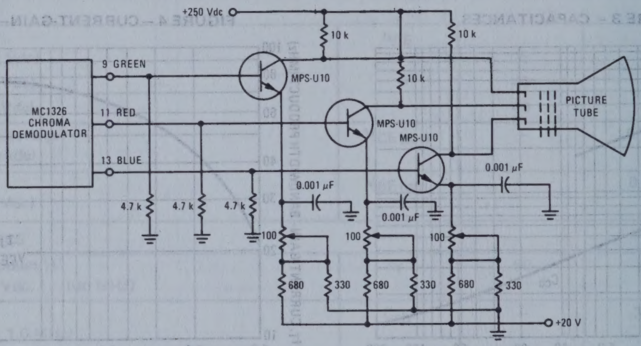
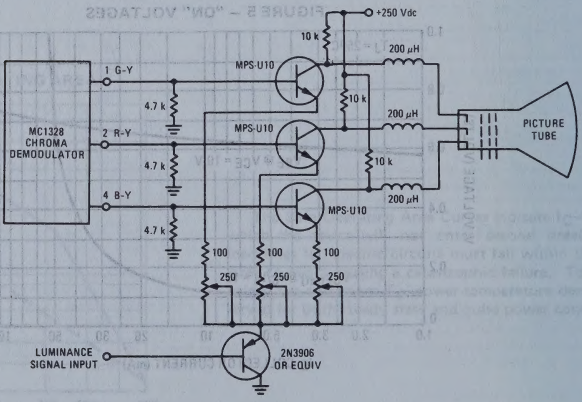

+250 Vdc
10 k
10 k
10 k
9 GREEN
11 RED
13 BLUE
MC1326
CHROMA
DEMODULATOR
MPS-U10
MPS-U10
MPS-U10
PICTURE
TUBE
0.001 µF
0.001 µF
0.001 µF
4.7 k
4.7 k
4.7 k
100
100
100
680
330
680
330
680
330
+20 V

FIGURE 7 – MPS-U10 AS RGB OUTPUT, MATRIXING COLOR DIFFERENCE AND LUMINANCE INPUTS


+250 Vdc
10 k
10 k
10 k
200 µH
200 µH
200 µH
MPS-U10
MPS-U10
MPS-U10
1 G-Y
2 R-Y
4 B-Y
MC1328
CHROMA
DEMODULATOR
4.7 k
4.7 k
4.7 k
PICTURE
TUBE
100
100
100
250
250
250
LUMINANCE
SIGNAL INPUT
2N3906
OR EQUIV

MPS-U31 (SILICON)

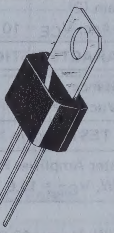
NPN SILICON ANNULAR RF TRANSISTOR

. . . designed for use in Citizen-Band and other high-frequency communications equipment operating to 30 MHz. Higher breakdown voltages allow a high percentage of up-modulation in AM circuits. This device is designed to be used with the MPS8000 driver and the MPS8001 RF oscillator.

- Output Power = 3.5 W (Min) @ V_{CC} = 13.6 Vdc
- Power Gain = 11.5 dB (Min)
- High Collector-Emitter Breakdown Voltage –
  $BV_{CES} \geqslant 65$ Vdc
- DC Current Gain –
  Linear to 500 mAdc

3.5 W – 27 MHz
RF POWER OUTPUT TRANSISTOR

NPN SILICON



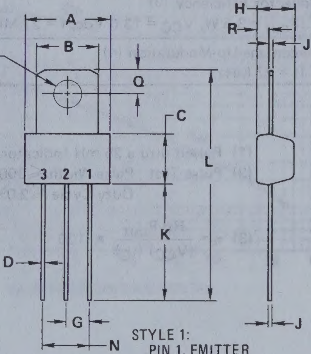
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	65	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	10 80	Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JA}$	12.5	$^oC/W$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	125	$^oC/W$

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 150 mAdc, V_{BE} = 0)	BV_{CES}	65	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	0.01	mAdc
ON CHARACTERISTICS					
DC Current Gain (2) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}	10	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	–	40	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 3.5 W, V_{CC} = 13.6 Vdc, f = 27 MHz)	G_{PE}	11.5	–	–	dB
Output Power (P_{in} = 350 mW, V_{CC} = 13.6 Vdc, f = 27 MHz)	P_{out}	3.5	–	–	Watts
Collector Efficiency (3) (P_{out} = 3.5 W, V_{CC} = 13.6 Vdc, f = 27 MHz)	η	–	85	–	%
Percentage Up-Modulation (4) (f = 27 MHz)	–	–	85	–	%

(1) Pulsed thru a 25 mH Indicator.

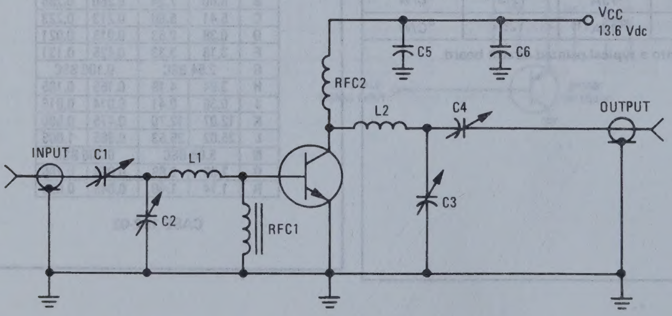
(2) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

(3) $\eta = \frac{R_F\,P_{out}}{(V_{CC})\,(I_C)} \bullet 100$

(4) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P_c) to 3.5 Watts with V_{CC} = 13.6 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_c}\right)^{1/2} - 1\right] \bullet 100$$

FIGURE 1 – 27 MHz TEST CIRCUIT



C1, C2	9.0-180 pF ARCO 463 or Equivalent
C3, C4	5.0-80 pF ARCO 462 or Equivalent
C5	0.02 μF Ceramic Disc
C6	0.1 μF Ceramic Disc
RFC1	4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B
RFC2	26 Turns #22 Enameled Wire (2 Layers – 13 Turns Each Layer) ¼″ Inner Diameter
L1	0.22 μH Molded Choke
L2	0.68 μH Molded Choke

POWER OUTPUT

FIGURE 2 – V_{CC} = 12.5 Vdc

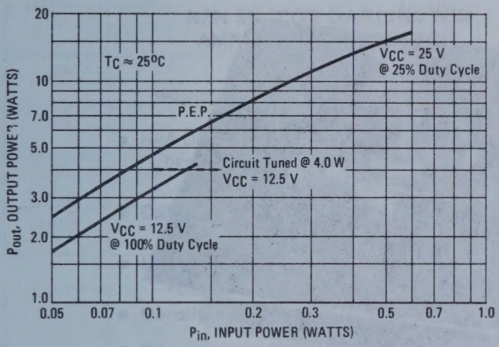


FIGURE 3 – V_{CC} = 13.6 Vdc

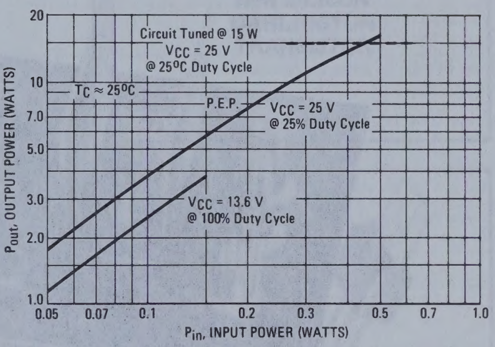


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

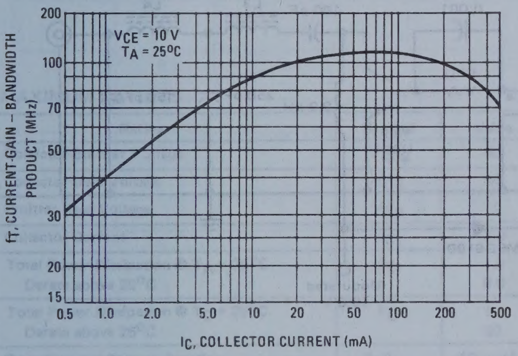


FIGURE 5 – CAPACITANCE

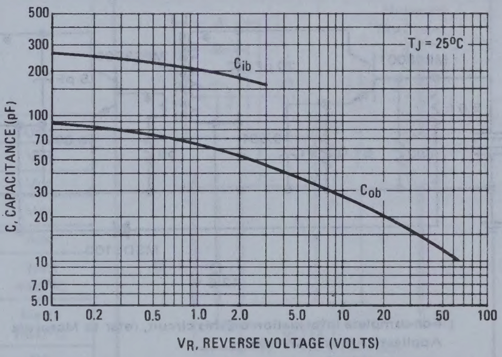


FIGURE 6 – DC CURRENT GAIN

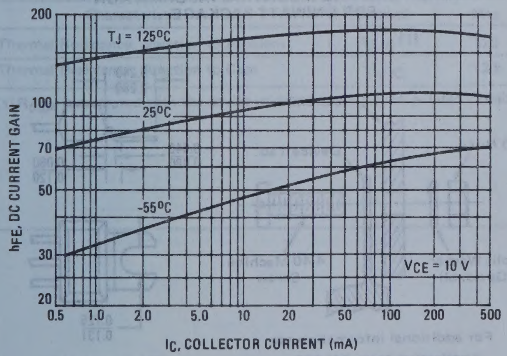


FIGURE 7 – ON VOLTAGES

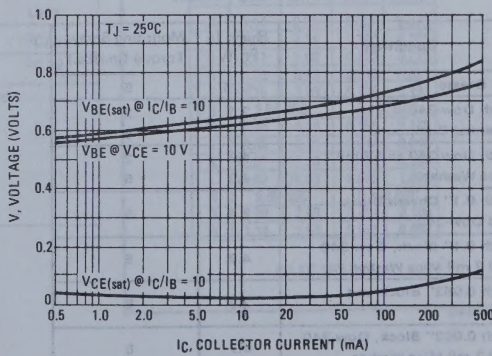
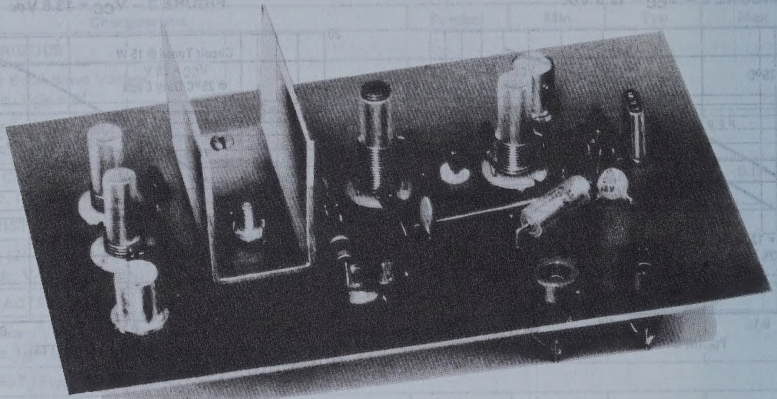
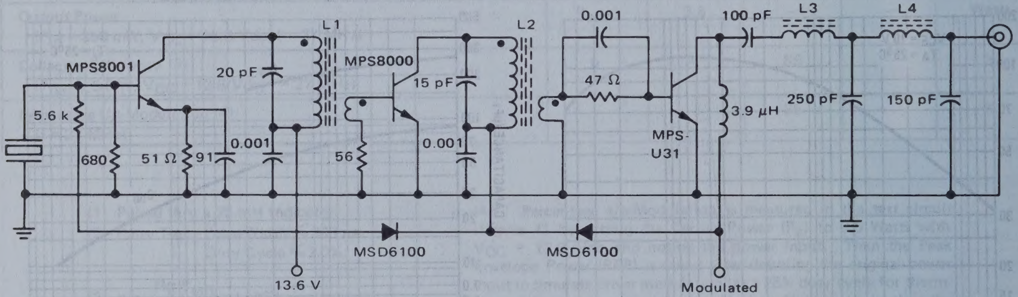


FIGURE 8 – TYPICAL APPLICATION – 27 MHz CITIZEN-BAND TRANSMITTER



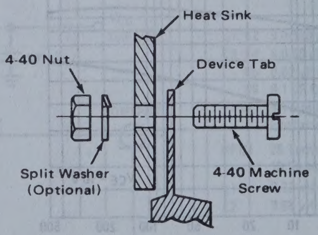

L1
L2
MPS8001
MPS8000
20 pF
15 pF
5.6 k
680
51 Ω
91
0.001
0.001
56
0.001
0.001
47 Ω
100 pF
L3
L4
3.9 μH
250 pF
150 pF
MPS-U31
MSD6100
MSD6100
13.6 V
Modulated 13.6 V

For complete information on this circuit, refer to Motorola Application Note, AN-596.

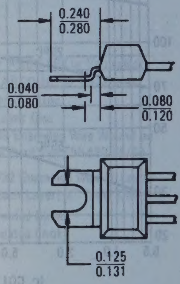
Case-(Tab)-to-Sink Thermal Resistances ($R_{\theta CS}$) for Common Mounting Methods

Condition	$R_{\theta CS}$ In °C/W	Mounting Screw Torque (in./lbs.)
No Grease	4.25	5
With Dow-340 Thermal Compound	2.1 1.7	2 5
With Dow-340 and 2 mil Mica Washer	4.7 4.3	2 5
With 0.1" Chassis Block and Dow-340	2.4	5
With 0.1" Block, Dow-340 and 2 mil Mica Washer	4.9	5
With 0.062" Block and Dow-340	2.2	5
With 0.062" Block, Dow-340 and 2 mil Mica Washer	4.7	5

LEAD FORM AND MOUNTING INFORMATION FOR UNIWATT PACKAGE


Heat Sink
4-40 Nut
Device Tab
Split Washer (Optional)
4-40 Machine Screw

For additional information see Application Note AN-472.


0.240
0.280
0.040
0.080
0.080
0.120
0.125
0.131

Tab formed for flush mounting order as MPS-U31-1

MPS-U45 (SILICON)

NPN SILICON DARLINGTON AMPLIFIER TRANSISTOR

. . . designed for amplifier and driver applications.

- High DC Current Gain —
  h_{FE} = 25,000 (Min) @ I_C = 200 mAdc
  15,000 (Min) @ I_C = 500 mAdc
- Collector-Emitter Breakdown Voltage —
  BV_{CES} = 40 Vdc (Min) @ I_C = 100 μAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.5 Vdc @ I_C = 1.0 Adc
- Monolithic Construction for High Reliability
- Complement to PNP MPS-U95

MAXIMUM RATINGS

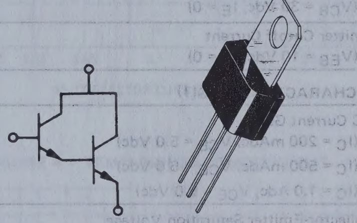
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	12	Vdc
Collector Current	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

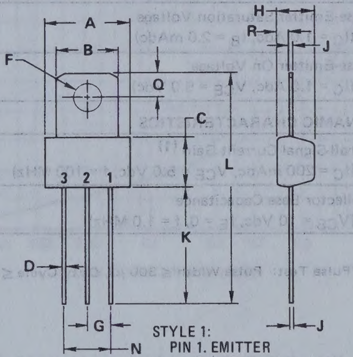
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON DARLINGTON TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	12	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				–
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)		25,000	65,000	150,000	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		15,000	35,000	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		4,000	12,000	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	1.2	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	1.85	2.0	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	1.7	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (1) (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	$\lvert h_{fe} \rvert$	1.0	3.2	–	–
Collector Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	2.5	6.0	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Uniwatt darlington transistors can be used in any number of low power applications, such as relay drivers, motor control and as general purpose amplifiers. As an audio amplifier these devices, when used as a complementary pair, can drive 3.5 watts into a 3.2 ohm speaker using a 14 volt supply with less than one per cent distortion. Because of the high gain the base drive requirement is as low as 1 mA in this application. They are also useful as power drivers for high current application such as voltage regulators.

FIGURE 1 – DC CURRENT GAIN

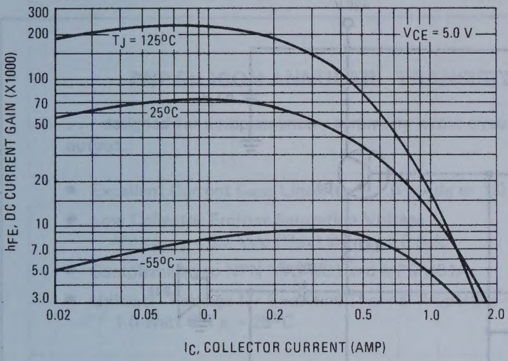


FIGURE 2 – SMALL-SIGNAL CURRENT GAIN

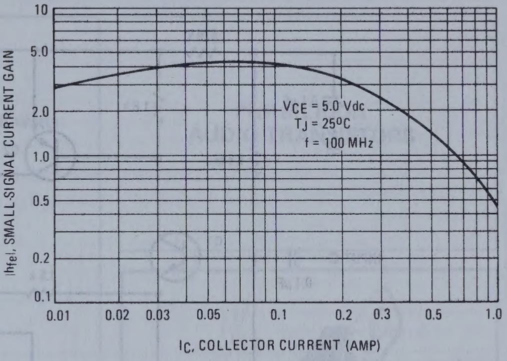


FIGURE 3 – "ON" VOLTAGES

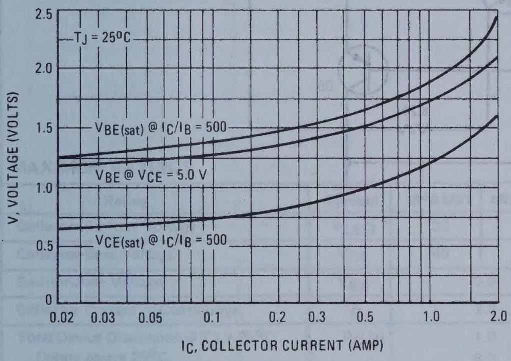


FIGURE 4 – TEMPERATURE COEFFICIENT

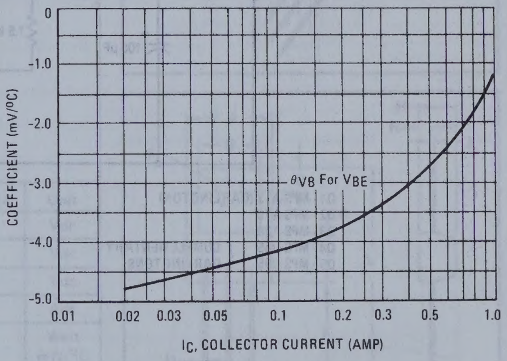
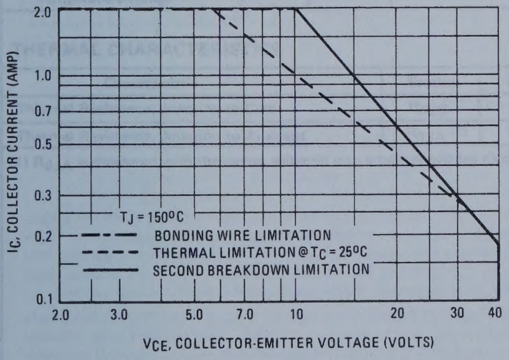


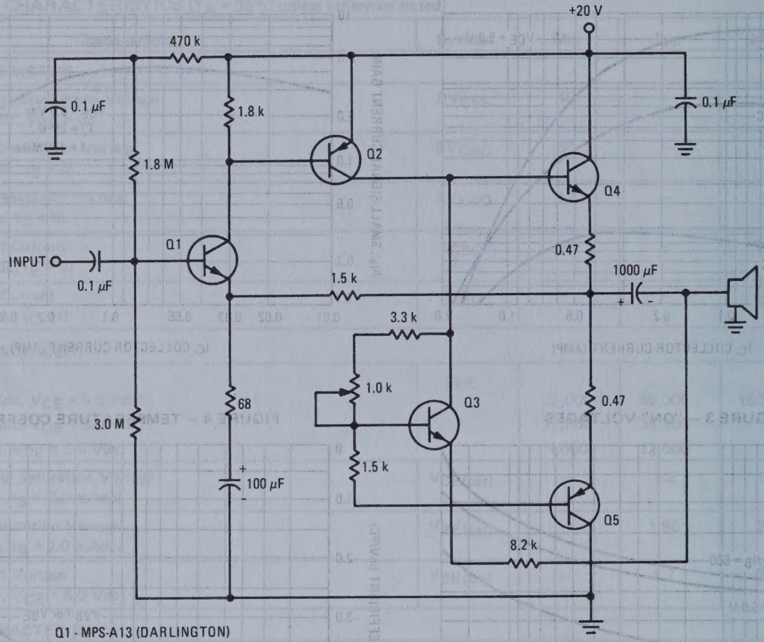
FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

5-WATT AUDIO AMPLIFIER


+20 V
470 k
0.1 μF
1.8 k
Q2
1.8 M
0.1 μF
Q4
Q1
INPUT
0.1 μF
1.5 k
0.47
1000 μF
+
-
8 Ω
3.3 k
1.0 k
Q3
68
3.0 M
0.47
1.5 k
+
100 μF
-
Q5
8.2 k

Q1 - MPS-A13 (DARLINGTON)
Q2 - MPS-A70
Q3 - MPS-A20
Q4 - MPS-U45 } COMPLEMENTARY
Q5 - MPS-U95 } DARLINGTONS

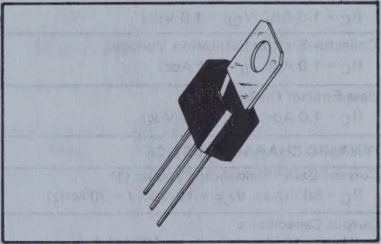
MPS-U51 (SILICON)
MPS-U51A

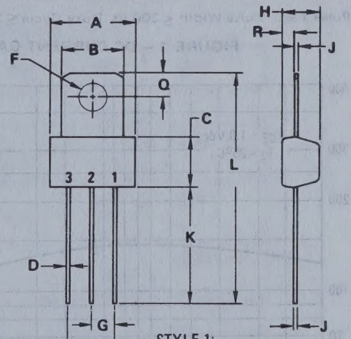
PNP SILICON ANNULAR TRANSISTORS

. . . designed for complementary symmetry audio circuits to 5 Watts output.

- Excellent Current Gain Linearity — 1.0 mAdc to 1.0 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- Complements to NPN MPS-U01 and MPS-U01A
- Uniwatt Package for Excellent Thermal Properties — 1.0 Watt @ T_A = 25°C

PNP SILICON
AUDIO TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

MAXIMUM RATINGS

Rating	Symbol	MPS-U51	MPS-U51A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	1.0 8.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D (1)	10 80		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.

MPS-U51,MPS-U51A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0) MPS-U51 MPS-U51A	BV_{CEO}	 30 40	 – –	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) MPS-U51 MPS-U51A	BV_{CBO}	 40 50	 – –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) MPS-U51 (V_{CB} = 40 Vdc, I_E = 0) MPS-U51A	I_{CBO}	 – –	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	 55 60 50	 – – –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	–	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	30	pF

(1) Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.

FIGURE 1 – DC CURRENT GAIN

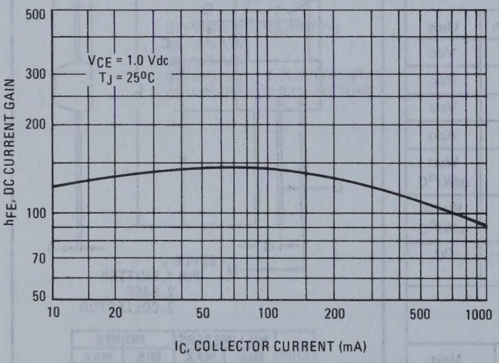


FIGURE 2 – "ON" VOLTAGES

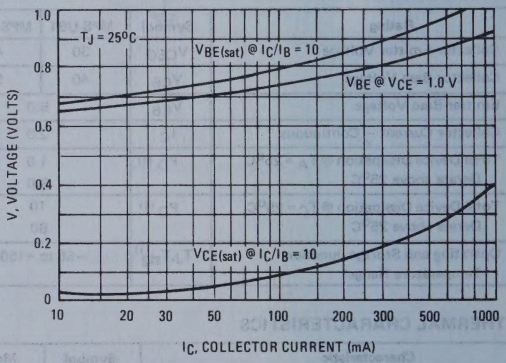
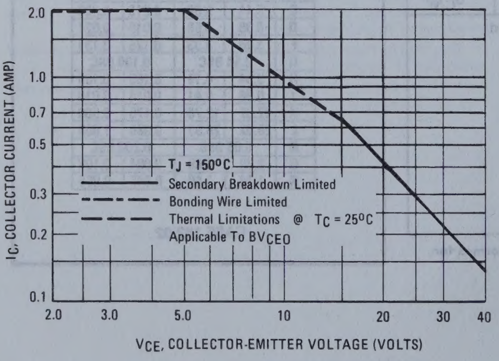


FIGURE 3 – DC SAFE OPERATING AREA

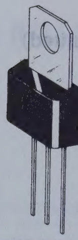


There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = **150°C**; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

MPS-U52 (SILICON)

PNP silicon annular amplifier transistor designed for general-purpose amplifier and driver applications. Complement to NPN MPS-U02.



CASE 152

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D (1)	1.0 8.0	Watt mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D (1)	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$ (1)	125	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\mu$Adc, $I_E = 0$)	BV_{CBO}	60	-	Vdc
Collector Cutoff Current ($V_{CB} = 40$ Vdc, $I_E = 0$)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS (2)				
DC Current Gain	h_{FE}			-
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		50	-	
($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)		50	300	
($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc)		30	-	
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (2) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	150	-	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	-	24	pF

(1) $R_{\theta JA}$ is measured with device soldered into a typical printed circuit board

(2) Pulse Test: Pulse Width≤300 μs, Duty Cycle≤2.0%

Uniwatt packages can be To-5 lead formed by adding -5 to the device title and tab formed for flush mounting by adding -1 to the device title.

FIGURE 1 – DC CURRENT GAIN

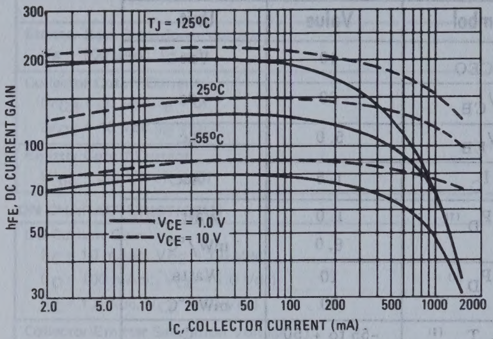


FIGURE 2 – "ON" VOLTAGES

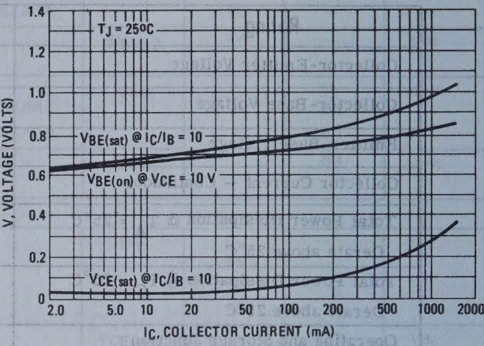


FIGURE 3 – COLLECTOR SATURATION REGION

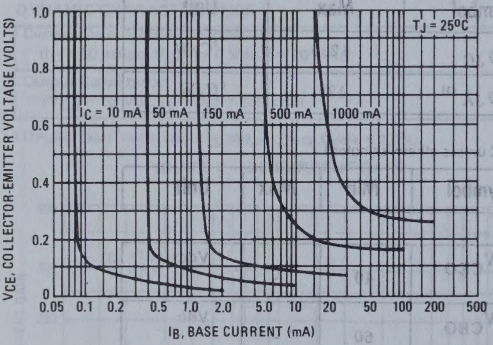


FIGURE 4 – DC SAFE OPERATING AREA

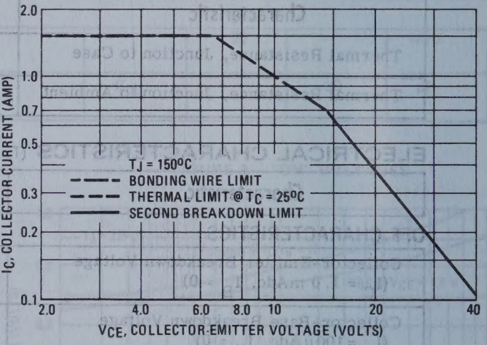


FIGURE 5 – CURRENT-GAIN BANDWIDTH PRODUCT

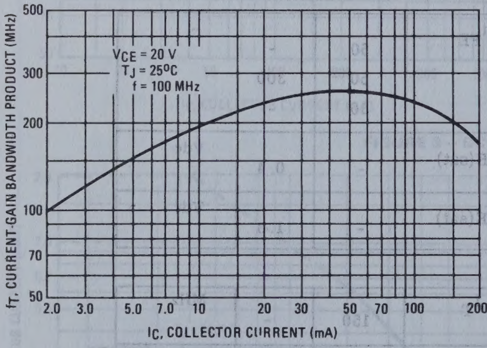
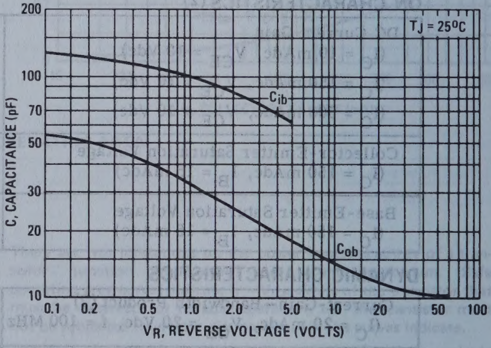


FIGURE 6 – CAPACITANCE



MPS-U55 (SILICON)
MPS-U56

PNP SILICON ANNULAR AMPLIFIER TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U55
  80 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U56
- High Power Dissipation – P_D = 10 W @ T_C = 25°C
- Complements to NPN MPS-U05 and MPS-U06

MAXIMUM RATINGS

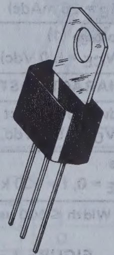
Rating	Symbol	MPS-U55	MPS-U56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	2.0		Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

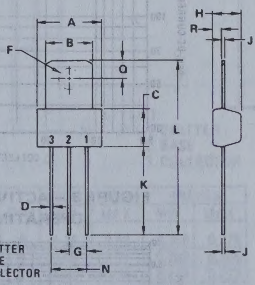
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

PNP SILICON AMPLIFIER TRANSISTORS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

Collector Connected
to Tab
CASE 152-02

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	 MPS-U55 MPS-U56	BV_{CEO}	 60 80	 – –	 – –	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0)	 MPS-U55 MPS-U56	I_{CBO}	 – –	 – –	 100 100	nAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 80 50 –	 160 130 80	 – – –	–
Collector-Emitter Saturation Voltage (1) (I_C = 250 mAdc, I_B = 10 mAdc) (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{CE(sat)}$	 – –	 0.22 0.15	 0.5 –	Vdc
Base-Emitter On Voltage (1) (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.78	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (1) (I_C = 250 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	10	15	pF

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – DC CURRENT GAIN

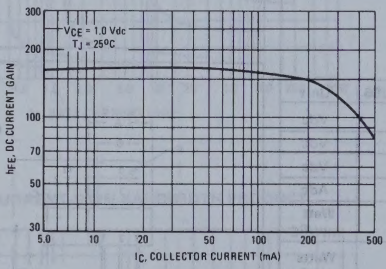


FIGURE 2 – "ON" VOLTAGES

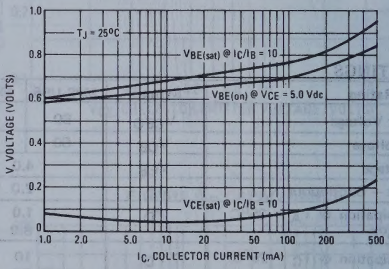


FIGURE 3 – ACTIVE-REGION SAFE OPERATING AREA

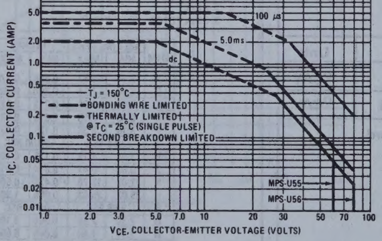
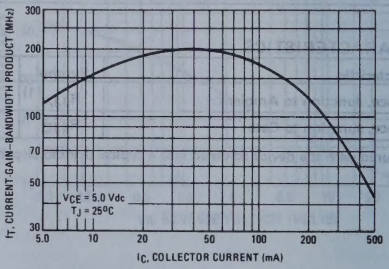


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415A)

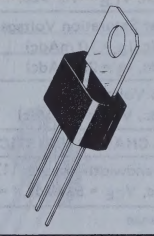
MPS-U57 (SILICON)

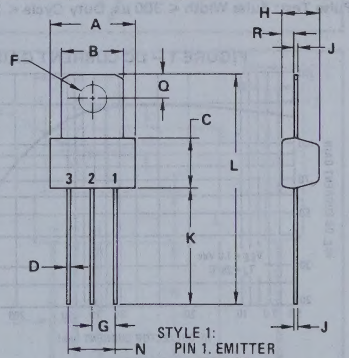
PNP SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 100 Vdc (Min) @ I_C = 1.0 mAdc
- High Power Dissipation — P_D = 10 W @ T_C = 25°C
- Complement to NPN MPS-U07

AMPLIFIER TRANSISTOR
PNP SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	125	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		60	140	–	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		30	65	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		–	30	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 250 mAdc, I_B = 10 mAdc)		–	0.24	0.5	
(I_C = 250 mAdc, I_B = 25 mAdc)		–	0.15	–	
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.78	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 200 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	50	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	15	pF

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DC CURRENT GAIN

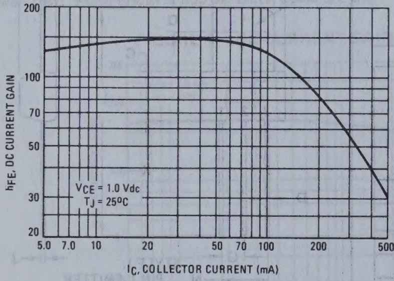


FIGURE 2 – "ON" VOLTAGES

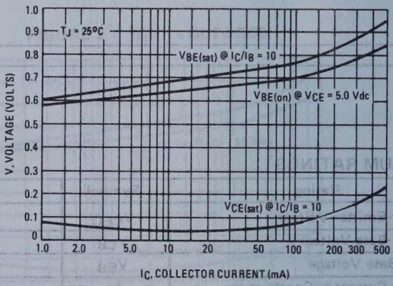


FIGURE 3 – DC SAFE OPERATING AREA

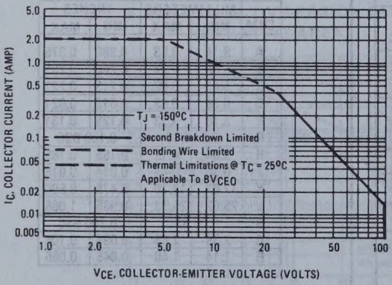
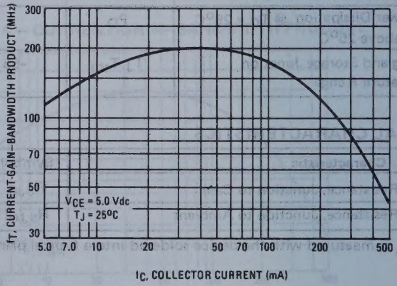


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

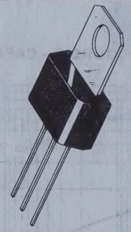
MPS-U60 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose applications requiring high breakdown voltages, low saturation voltages and low capacitance.

- Complement to NPN Type MPS-U10

PNP SILICON
HIGH VOLTAGE
TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 8.0	Watt mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	10 80	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

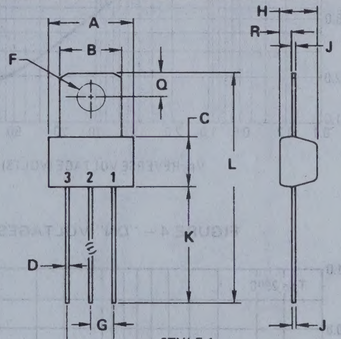
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	12.5	$^oC/W$
Thermal Resistance, Junction to Ambient	$R\theta_{JA}$ (1)	125	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Emitter Breakdown Voltage (2) ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	300	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	BV_{CBO}	300	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current ($V_{CB} = 200$ Vdc, $I_E = 0$)	I_{CBO}	–	0.2	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (2)	h_{FE}			–
($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc)		25	–	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)		30	–	
($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)		30	–	
Collector-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$	–	0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 20$ mAdc, $I_B = 2.0$ mAdc)	$V_{BE(sat)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (2) ($I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)	f_T	60	–	MHz
Collector-Base Capacitance ($V_{CB} = 20$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	–	8.0	pF

(1) $R\theta_{JA}$ is measured with the device soldered into a typical printed circuit board.

(2) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

FIGURE 1 – DC CURRENT GAIN

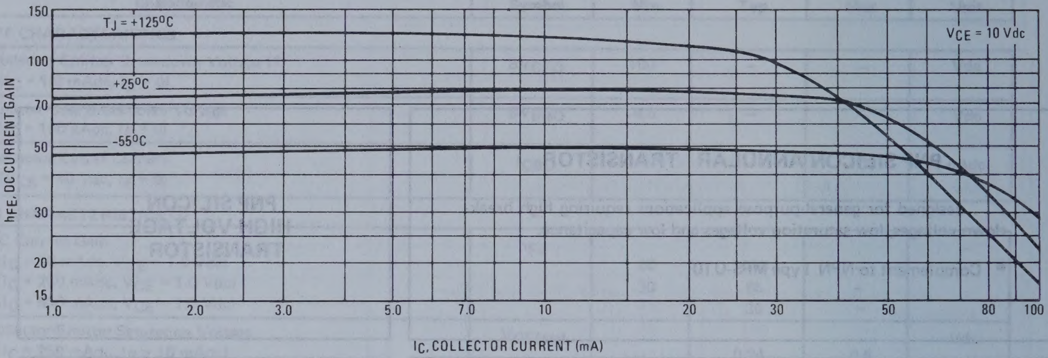


FIGURE 2 – CAPACITANCES

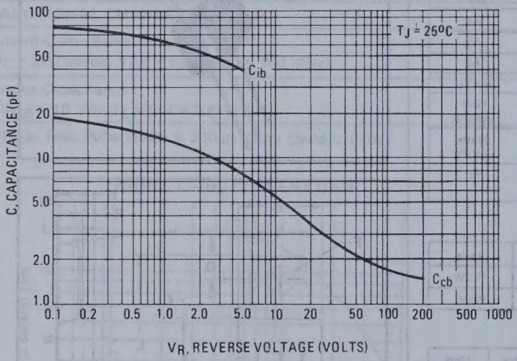


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

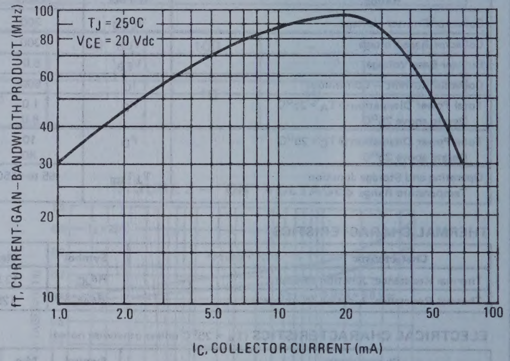


FIGURE 4 – "ON" VOLTAGES

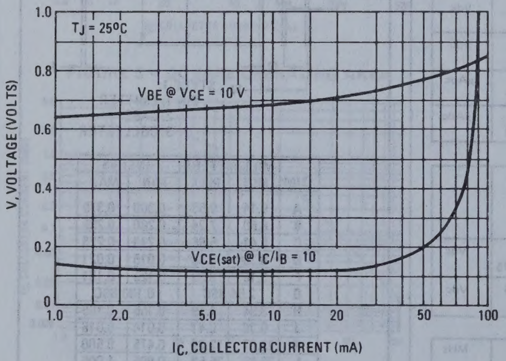
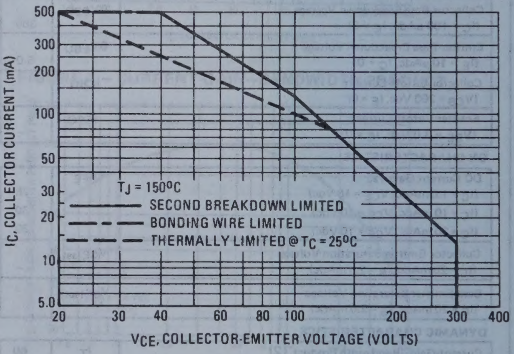


FIGURE 5 – DC SAFE OPERATING AREA



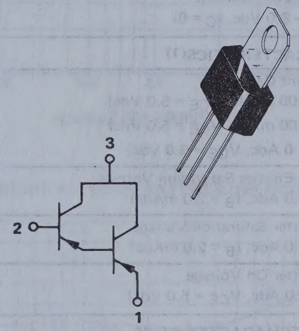
MPS-U95 (SILICON)

PNP SILICON DARLINGTON AMPLIFIER TRANSISTOR

. . . designed for amplifier and driver applications.

- High DC Current Gain —
  h_{FE} = 25,000 (Min) @ I_C = 200 mAdc
  15,000 (Min) @ I_C = 500 mAdc
- Collector-Emitter Breakdown Voltage —
  BV_{CES} = 40 Vdc (Min) @ I_C = 100 μAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.5 Vdc @ I_C = 1.0 Adc
- Monolithic Construction for High Reliability
- Complement to NPN MPS-U45

PNP SILICON DARLINGTON TRANSISTOR



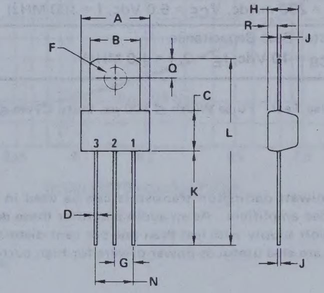
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current -Continuous	I_C	2.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 80	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	125	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$ (1)	12.5	°C/W

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.14	9.53	0.360	0.375
B	6.60	7.24	0.260	0.285
C	5.41	5.66	0.213	0.223
D	0.38	0.53	0.015	0.021
F	3.18	3.33	0.125	0.131
G	2.54 BSC		0.100 BSC	
H	3.94	4.19	0.155	0.165
J	0.36	0.41	0.014	0.016
K	12.07	12.70	0.475	0.500
L	25.02	25.53	0.985	1.005
N	5.08 BSC		0.200 BSC	
Q	2.39	2.69	0.094	0.106
R	1.14	1.40	0.045	0.055

CASE 152-02

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu$Adc, $V_{BE} = 0$)	BV_{CES}	40	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	BV_{CBO}	50	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	10	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current ($V_{EB} = 8.0$ Vdc, $I_C = 0$)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				–
($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc)		25,000	43.000	150,000	
($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)		15,000	41,000	–	
($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)		4,000	35,000	–	
Collector-Emitter Saturation Voltage ($I_C = 1.0$ Adc, $I_B = 2.0$ mAdc)	$V_{CE(sat)}$	–	1.0	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0$ Adc, $I_B = 2.0$ mAdc)	$V_{BE(sat)}$	–	1.85	2.0	Vdc
Base-Emitter On Voltage ($I_C = 1.0$ Adc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	–	1.7	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (1) ($I_C = 200$ mAdc, $V_{CE} = 5.0$ Vdc, f = 100 MHz)	$\lvert h_{fe}\rvert$	0.5	1.6	–	–
Collector Base Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{cb}	–	2.5	12	pF

(1) Pulse Test: Pulse Width $\leq 300\ \mu s$, Duty Cycle $\leq 2.0\%$.

Uniwatt darlington transistors can be used in any number of low power applications, such as relay drivers, motor control and as general purpose amplifiers. As an audio amplifier these devices, when used as a complementary pair, can drive 3.5 watts into a 3.2 ohm speaker using a 14 volt supply with less than one per cent distortion. Because of the high gain the base drive requirement is as low as 1 mA in this application. They are also usefui as power drivers for high current application such as voltage regulators.

FIGURE 1 – DC CURRENT GAIN

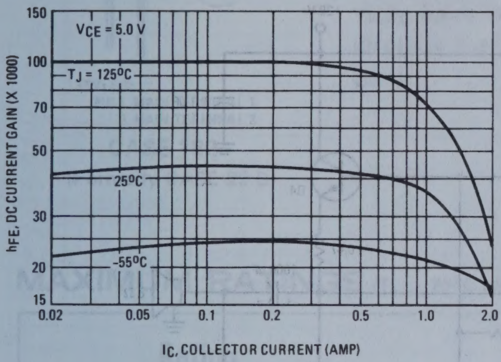


FIGURE 2 – SMALL-SIGNAL CURRENT GAIN

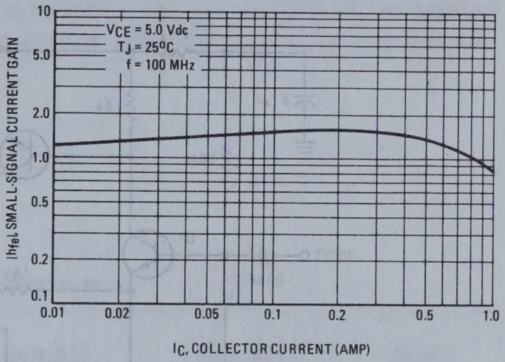


FIGURE 3 – "ON" VOLTAGES

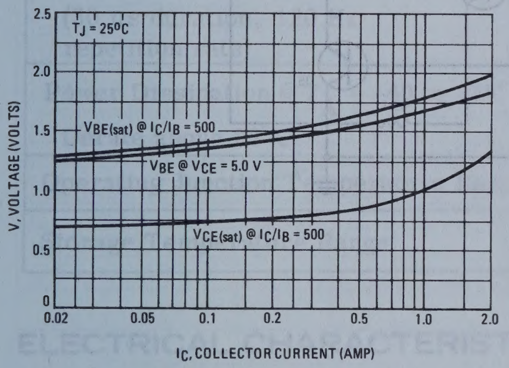


FIGURE 4 – TEMPERATURE COEFFICIENT

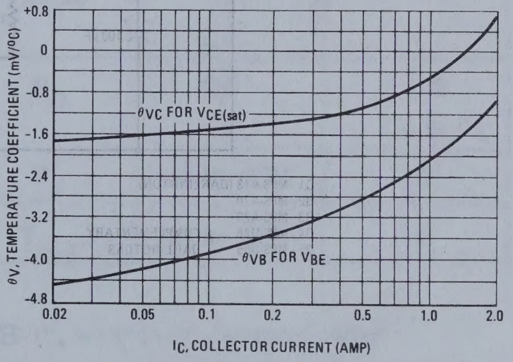
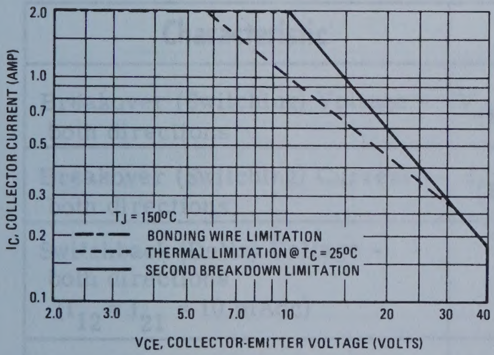


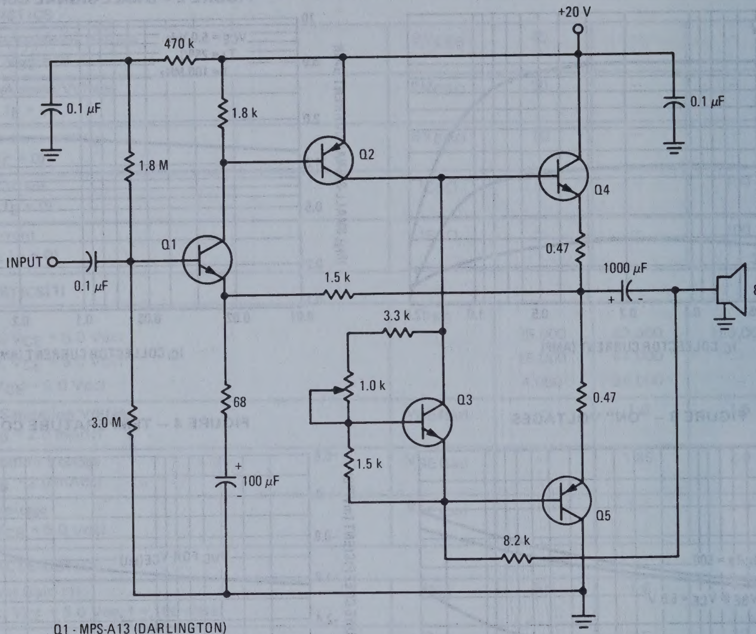
FIGURE 5 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

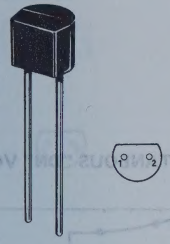
The data of Figure 5 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

5-WATT AUDIO AMPLIFIER


+20 V
470 k
0.1 µF
1.8 k
Q2
0.1 µF
1.8 M
Q4
Q1
0.47
INPUT
0.1 µF
1.5 k
1000 µF
+
-
8 Ω
3.3 k
1.0 k
68
Q3
0.47
3.0 M
1.5 k
+
100 µF
-
Q5
8.2 k

Q1 - MPS-A13 (DARLINGTON)
Q2 - MPS-A70
Q3 - MPS-A20
Q4 - MPS-U45 { COMPLEMENTARY
Q5 - MPS-U95 { DARLINGTONS

MPT20 (SILICON)



STYLE 3:
PIN 1. MAIN TERMINAL 1
2. MAIN TERMINAL 2

CASE 182
(Formerly CASE 29 B)

Plastic silicon 3-layer bilateral triggers are two-terminal devices that exhibit bi-directional negative resistance switching characteristics. These economical, durable devices have been developed for use in thyristor triggering circuits for lamp drivers and universal motor speed controls.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Pulse Current (30 μs duration, 120 Hz repetition rate)	I_{pulse}	2.0	Amp
Power Dissipation @ T_A = -40 to +25°C	P_D	300	mW
Derate above 25°C		4.0	mW/°C
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Plastic Trigger (MPT) devices have bi-directional characteristics and as such the terminal leads are interchangeable. For purposes of symbol clarification, the leads have arbitrarily been designated 1 and 2. A 12 designation indicates that terminal 1 is positive with respect to terminal 2, vice versa for a 21 designation. (See Figure 1)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakover (Switching) Voltage - both directions	$V_{(BR)12}$ & $V_{(BR)21}$	16	20	24	Volt
Breakover (Switching) Current - both directions	$I_{(BR)12}$ & $I_{(BR)21}$	-	35	100	μAmp
Switchback (Delta) Voltage - both directions ($I_{12} = I_{21}$ = 10 mAdc)	ΔV_{12} & ΔV_{21}	5.0	7.0	-	Volt
Peak Blocking Current - both directions Voltage Applied = 14 V	$I_{(BL)12}$ & $I_{(BL)21}$	-	0.5	10	μA

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – VOLT-AMPERE CHARACTERISTICS

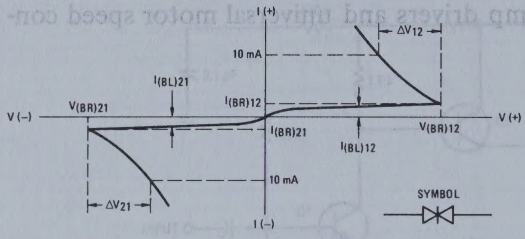

I (+)
ΔV12
10 mA
I(BL)21
I(BR)12
V(BR)21
V (–)
V (+)
I(BR)21
V(BR)12
I(BL)12
10 mA
SYMBOL
ΔV21
I (–)

FIGURE 2 – INSTANTANEOUS "ON" VOLTAGE

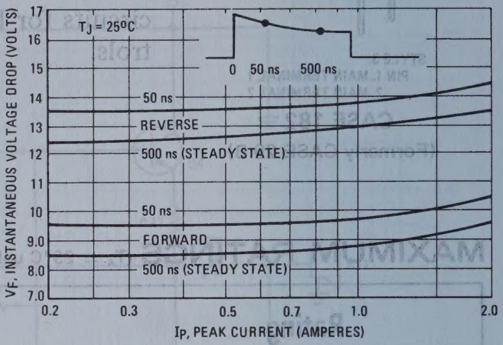


FIGURE 3 – BREAKOVER VOLTAGE BEHAVIOR

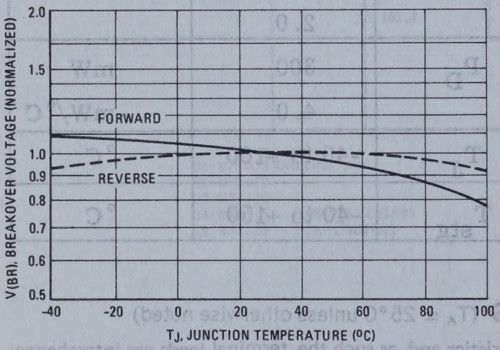


FIGURE 4 – NORMALIZED OUTPUT VOLTAGE BEHAVIOR

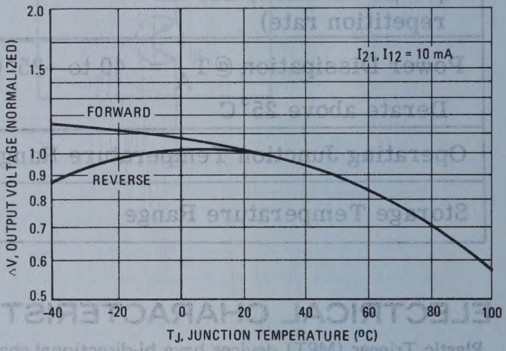


FIGURE 5 – SWITCHING TIMES

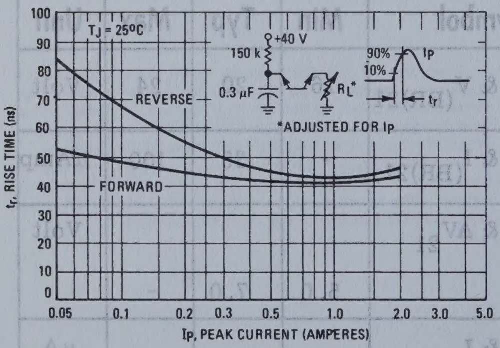
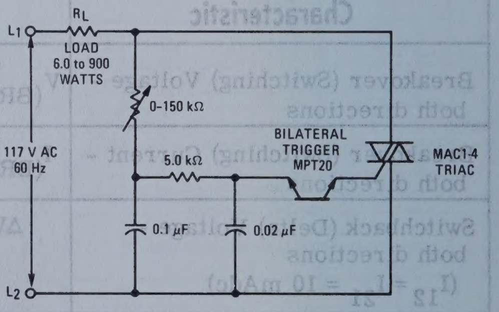
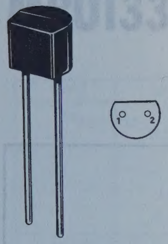


FIGURE 6 – CONTROL CIRCUIT


L1
RL
LOAD
6.0 to 900
WATTS
0-150 kΩ
117 V AC
60 Hz
5.0 kΩ
BILATERAL
TRIGGER
MPT20
MAC1-4
TRIAC
0.1 μF
0.02 μF
L2

MPT28 (SILICON)
MPT32



Plastic silicon annular 3-layer bilateral triggers, two-terminal devices which exhibit symmetrical negative resistance switching characteristics. These economical, durable devices have been developed for use in thyristor triggering circuits, signal switching and detection circuits.

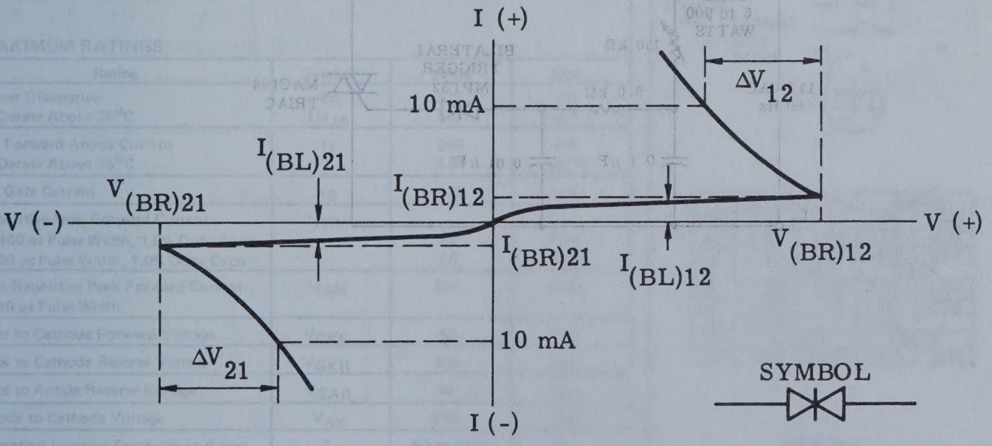
CASE 182
(Formerly CASE 29 B)

STYLE 3:
PIN 1. MAIN TERMINAL 1
2. MAIN TERMINAL 2

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Pulse Current (30 µs duration, 120 Hz repetition rate)	I_{pulse}	2.0	Amp
Power Dissipation @ T_A = -40 to +25°C Derate above 25°C	P_D	300 4.0	mW mW/°C
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

FIGURE 1 — VOLT AMPERE CHARACTERISTICS

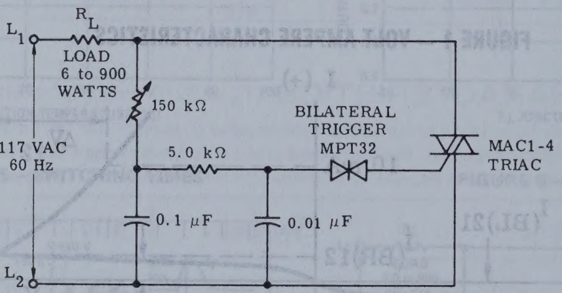


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

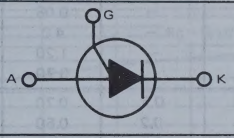
Characteristic	Symbol	Min	Typ	Max	Unit
Breakover (switching) Voltage – both directions MPT28 MPT32	$V_{(BR)12}$ & $V_{(BR)21}$	 24 28	 28 32	 32 36	Volt
Breakover (switching) Current – both directions	$I_{(BR)12}$ & $I_{(BR)21}$	-	20	50	μAmp
Switchback (delta) Voltage – both directions MPT28 MPT32	ΔV_{12} & ΔV_{21}	 7.0 7.0	 10 10	 - -	Volt
Peak Blocking Current – both directions Voltage Applied = 18 V	$I_{(BL)12}$ & $I_{(BL)21}$	-	0.5	10	μA
Breakover (switching) Voltage Temperature Coefficient, T_A = -40°C to +100°C		-	0.03	-	%/°C

Plastic trigger devices have symmetrical characteristics and as such the terminal leads are interchangeable. For purposes of symbol clarification, the leads have arbitrarily been designated 1 and 2. A 12 designation indicates that terminal 1 is positive with respect to terminal 2, vice versa for a 21 designation.

FIGURE 2 — TYPICAL CONTROL CIRCUIT

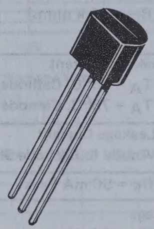


MPU131 (SILICON)
thru
MPU133



SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

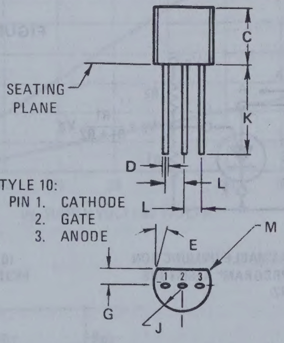
40 VOLTS
375 mW



SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

. . . designed to enable the engineer to "program" unijunction characteristics such as R_{BB}, η, I_V, and I_P by merely selecting two resistor values. Application includes thyristor-trigger, oscillator, pulse and timing circuits. The MPU131, MPU132 and MPU133 may also be used in special thyristor applications due to the availability of an anode gate. Supplied in an inexpensive TO-92 plastic package for high-volume requirements, this package is readily adaptable for use in automatic insertion equipment.

- Programmable — R_{BB}, η, I_V and I_P.
- Low On-State Voltage — 1.5 Volts Maximum @ I_F = 50 mA
- Low Gate to Anode Leakage Current — 5.0 nA Maximum
- High Peak Output Voltage — 11 Volts Typical
- Low Offset Voltage — 0.35 Volt Typical (R_G = 10 k ohms)



STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
C	4.450	4.700	0.175	0.185
D	0.407	0.482	0.016	0.019
E	5° NOM		5° NOM	
G	1.150	1.390	0.045	0.055
J	2.160	2.420	0.085	0.095
K	12.700	–	0.500	–
L	1.270 TP		0.050 TP	
M	0.076	0.330	0.003	0.013

CASE 29-01

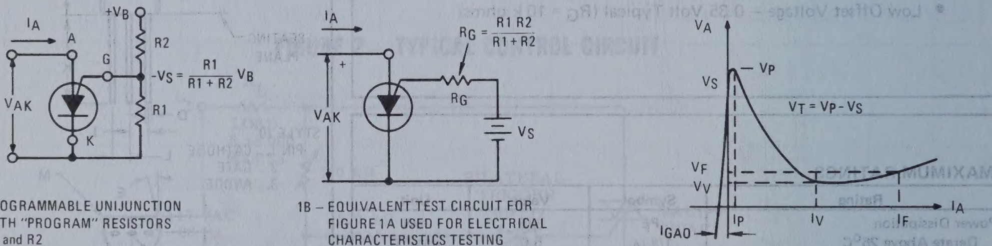
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation Derate Above 25°C	P_F $1/\theta_{JA}$	375 5.0	mW mW/°C
DC Forward Anode Current Derate Above 25°C	I_T	200 2.67	mA mA/°C
DC Gate Current	I_G	±20	mA
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle 20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 2.0	 Amp Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	5.0	Amp
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt
Operating Junction Temperature Range	T_J	-50 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Figure	Symbol	Min	Typ	Max	Unit
Peak Current (V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU131 MPU132 MPU133	2,9–14	I_P	– – –	1.25 0.19 0.08	2.0 0.30 0.15	μA
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU131 MPU132 MPU133			– – –	4.0 1.20 0.70	5.0 2.0 1.0	
Offset Voltage (V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU131 MPU132 MPU133	1	V_T	0.2 0.2 0.2	0.70 0.50 0.40	1.6 0.6 0.6	Volts
(V_S = 10 Vdc, R_G = 10 k ohms) (All Types)				0.2	0.35	0.6	
Valley Current (V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU131, 132 MPU133	1,4,5,	I_V	– –	18 18	50 25	μA
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU131 MPU132, 133			70 50	270 270	– –	
Gate to Anode Leakage Current (V_S = 40 Vdc, T_A = 25°C, Cathode Open) (V_S = 40 Vdc, T_A = 75°C, Cathode Open)		–	I_{GAO}	– –	1.0 30	5.0 75	nAdc
Gate to Cathode Leakage Current (V_S = 40 Vdc, Anode to Cathode Shorted)		–	I_{GKS}	–	5.0	50	nAdc
Forward Voltage (I_F = 50 mA Peak)		1,6	V_F	–	0.8	1.5	Volts
Peak Output Voltage (V_B = 20 Vdc, C_C = 0.2 μF)		3,7	V_o	6.0	11	–	Volts
Pulse Voltage Rise Time (V_B = 20 Vdc, C_C = 0.2 μF)		3	t_r	–	40	80	ns

FIGURE 1 – ELECTRICAL CHARACTERIZATION



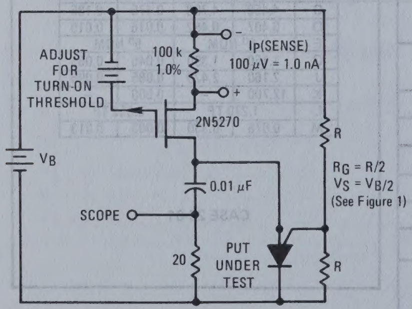
I_A
A
+V_B
R2
G
$-V_S = \frac{R1}{R1+R2} V_B$
V_{AK}
R1
K
I_A
$R_G = \frac{R1\ R2}{R1+R2}$
+
V_{AK}
R_G
V_S
V_A
V_S
V_P
$V_T = V_P - V_S$
V_F
V_V
I_P
I_V
I_F
I_A
I_{GAO}

1A – PROGRAMMABLE UNIJUNCTION WITH "PROGRAM" RESISTORS R1 and R2

1B – EQUIVALENT TEST CIRCUIT FOR FIGURE 1A USED FOR ELECTRICAL CHARACTERISTICS TESTING (ALSO SEE FIGURE 2)

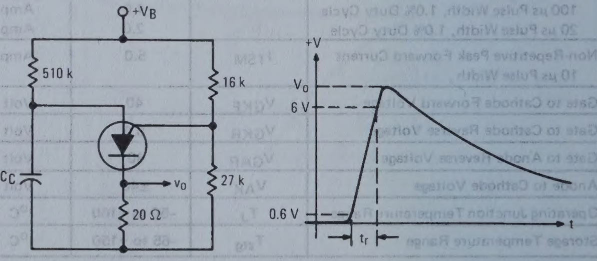
1C – ELECTRICAL CHARACTERISTICS

FIGURE 2 – PEAK CURRENT (I_P) TEST CIRCUIT



ADJUST FOR TURN-ON THRESHOLD
100 k 1.0%
–
I_P(SENSE) 100 μV = 1.0 nA
+
2N5270
V_B
0.01 μF
R
$R_G = R/2$
$V_S = V_B/2$
(See Figure 1)
SCOPE
20
PUT UNDER TEST
R

FIGURE 3 – V_o AND t_r TEST CIRCUIT



+V_B
510 k
16 k
C_C
v_o
27 k
20 Ω
+V
V_o
6 V
0.6 V
t_r
t

TYPICAL VALLEY CURRENT BEHAVIOR

FIGURE 4 – EFFECT OF SUPPLY VOLTAGE

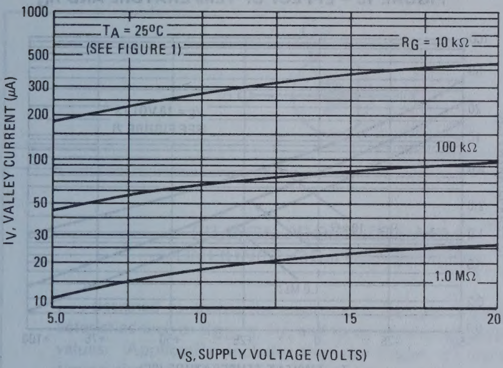


FIGURE 5 – EFFECT OF TEMPERATURE

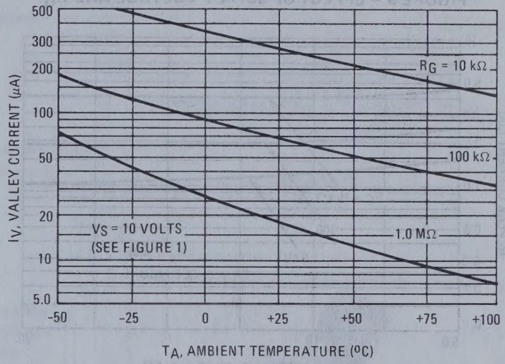


FIGURE 6 – FORWARD VOLTAGE

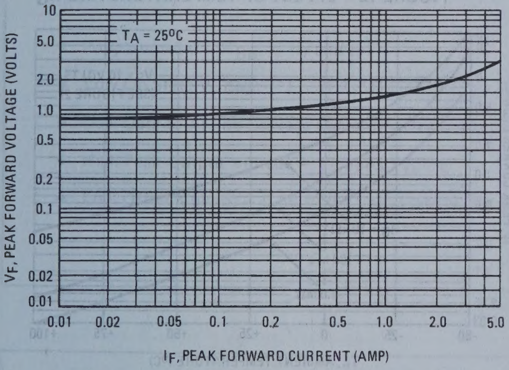


FIGURE 7 – PEAK OUTPUT VOLTAGE

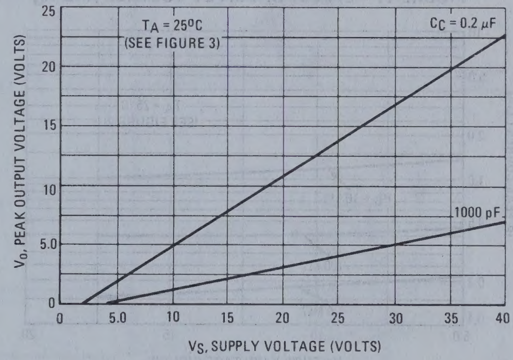
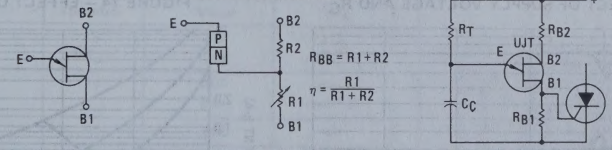


FIGURE 8 – STANDARD UNIJUNCTION COMPARED TO PROGRAMMABLE UNIJUNCTION

STANDARD UNIJUNCTION

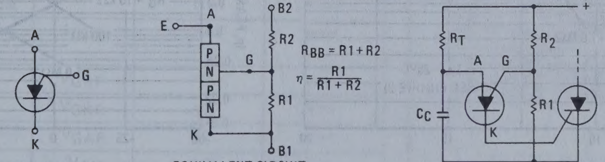

B2
E
B1
E
P
N
B2
R2
RBB = R1 + R2
η = R1/(R1 + R2)
R1
B1
+
RT
RB2
UJT
E
B2
B1
CC
RB1

CIRCUIT SYMBOL

EQUIVALENT CIRCUIT

TYPICAL APPLICATION

PROGRAMMABLE UNIJUNCTION


A
G
K
A
E
B2
R2
P
N
P
N
G
RBB = R1 + R2
η = R1/(R1 + R2)
R1
K
B1
+
RT
R2
A
G
CC
K
R1

CIRCUIT SYMBOL

EQUIVALENT CIRCUIT
WITH EXTERNAL "PROGRAM"
RESISTORS R1 and R2

TYPICAL APPLICATION

TYPICAL PEAK CURRENT BEHAVIOR

MPU131

FIGURE 9 – EFFECT OF SUPPLY VOLTAGE AND R_G

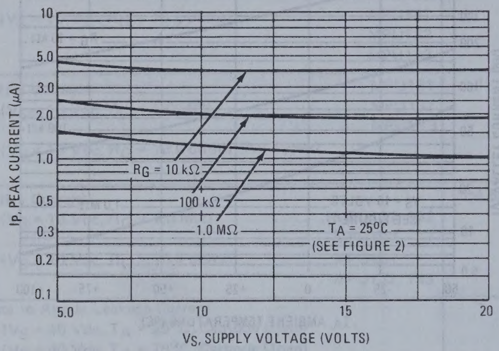
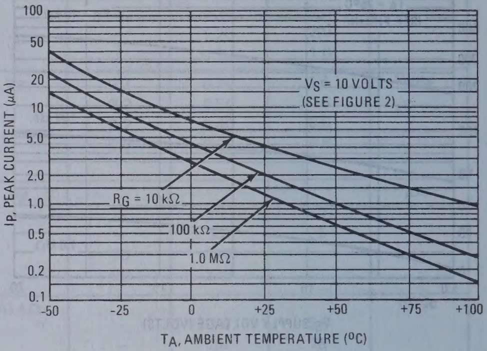


FIGURE 10 – EFFECT OF TEMPERATURE AND R_G



MPU132

FIGURE 11 – EFFECT OF SUPPLY VOLTAGE AND R_G

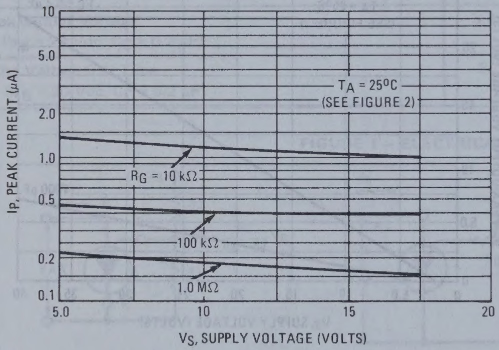
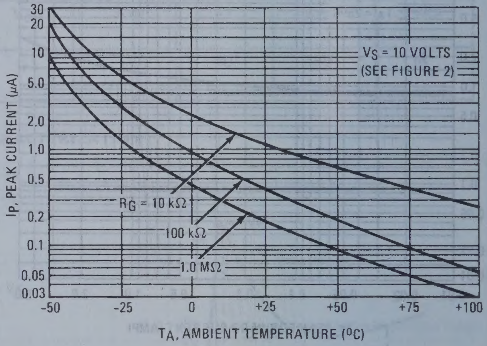


FIGURE 12 – EFFECT OF TEMPERATURE AND R_G



MPU133

FIGURE 13 – EFFECT OF SUPPLY VOLTAGE AND R_G

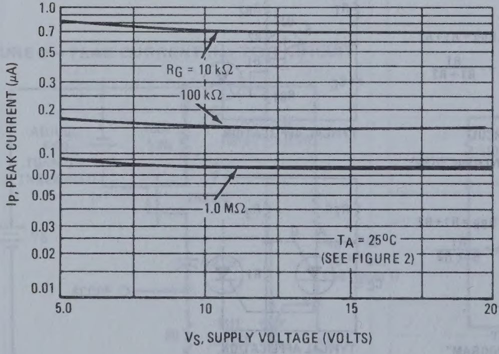
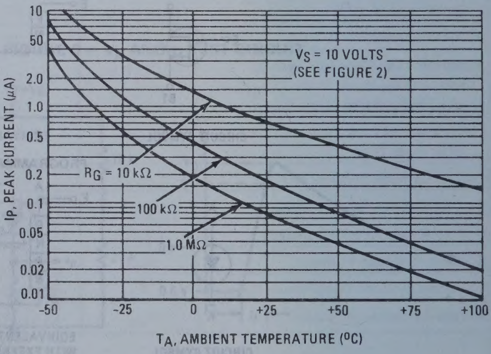
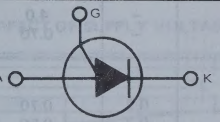


FIGURE 14 – EFFECT OF TEMPERATURE AND R_G



MPU6027, MPU6028 (SILICON)



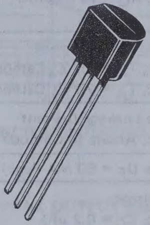
SILICON PROGRAMMABLE UNIJUNCTION TRANSISTORS

. . . designed to enable the engineer to "program" unijunction characteristics such as R_{BB}, η, I_V, and I_P by merely selecting two resistor values. Application includes thyristor-trigger, oscillator, pulse and timing circuits. These devices may also be used in special thyristor applications due to the availability of an anode gate. Supplied in an inexpensive TO-92 plastic package for high-volume requirements, this package is readily adaptable for use in automatic insertion equipment.

- Programmable – R_{BB}, η, I_V and I_P.
- Low On-State Voltage – 1.5 Volts Maximum @ I_F = 50 mA
- Low Gate to Anode Leakage Current – 10 nA Maximum
- High Peak Output Voltage – 11 Volts Typical
- Low Offset Voltage – 0.35 Volt Typical (R_G = 10 k ohms)

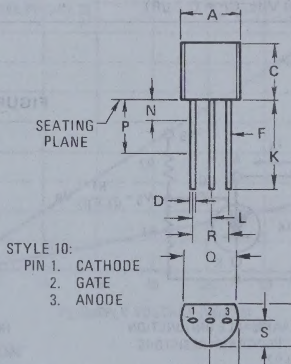
SILICON
PROGRAMMABLE UNIJUNCTION
TRANSISTORS

40 VOLTS
375 mW



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation(1) Derate Above 25°C	P_F $1/\theta_{JA}$	375 5.0	mW mW/°C
DC Forward Anode Current(2) Derate Above 25°C	I_T	200 2.67	mA mA/°C
DC Gate Current	I_G	±50	mA
Repetitive Peak Forward Current 100 μs Pulse Width, 1.0% Duty Cycle 20 μs Pulse Width, 1.0% Duty Cycle	I_{TRM}	 1.0 2.0	 Amp Amp
Non-Repetitive Peak Forward Current 10 μs Pulse Width	I_{TSM}	5.0	Amp
Gate to Cathode Forward Voltage	V_{GKF}	40	Volt
Gate to Cathode Reverse Voltage	V_{GKR}	-5.0	Volt
Gate to Anode Reverse Voltage	V_{GAR}	40	Volt
Anode to Cathode Voltage	V_{AK}	±40	Volt
Operating Junction Temperature Range	T_J	-50 to +100	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C



STYLE 10:
PIN 1. CATHODE
2. GATE
3. ANODE

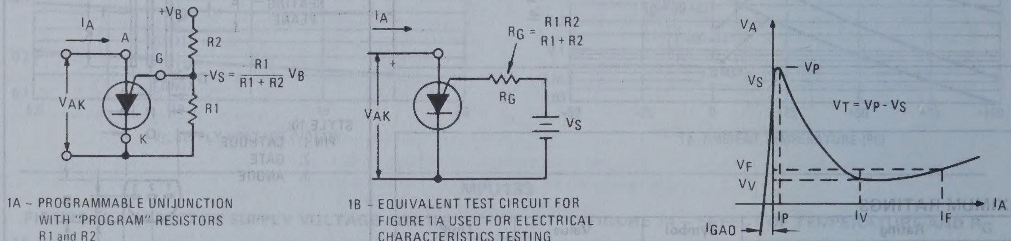
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Figure	Symbol	Min	Typ	Max	Unit
Peak Current		2,9,11	I_P				µA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU6027			–	1.25	2.0	
	MPU6028			–	0.08	0.15	
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU6027			–	4.0	5.0	
	MPU6028			–	0.70	1.0	
Offset Voltage		1	V_T				Volts
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU6027			0.2	0.70	1.6	
	MPU6028			0.2	0.50	0.6	
(V_S = 10 Vdc, R_G = 10 k ohms)	(Both Types)			0.2	0.35	0.6	
Valley Current		1,4,5,	i_V				µA
(V_S = 10 Vdc, R_G = 1.0 MΩ)	MPU6027			–	18	50	
	MPU6028			–	18	25	
(V_S = 10 Vdc, R_G = 10 k ohms)	MPU6027			70	270	–	
	MPU6028			25	270	–	
Gate to Anode Leakage Current		–	I_{GAO}				nAdc
(V_S = 40 Vdc, T_A = 25°C, Cathode Open)				–	1.0	10	
(V_S = 40 Vdc, T_A = 75°C, Cathode Open)				–	3.0	–	
Gate to Cathode Leakage Current		–	I_{GKS}				nAdc
(V_S = 40 Vdc, Anode to Cathode Shorted)				–	5.0	50	
Forward Voltage (I_F = 50 mA Peak)		1,6	V_F	–	0.8	1.5	Volts
Peak Output Voltage (V_B = 20 Vdc, C_C = 0.2 µF)		3,7	V_o	6.0	11	–	Volts
Pulse Voltage Rise Time (V_B = 20 Vdc, C_C = 0.2 µF)		3	t_r	–	40	80	ns

FIGURE 1 – ELECTRICAL CHARACTERIZATION


IA
A
+VB
R2
G
–VS = R1/(R1 + R2) VB
VAK
R1
K
IA
+
RG = R1 R2/(R1 + R2)
RG
VAK
VS
VA
VS
VP
VT = VP - VS
VF
VV
IA
IP
IV
IF
IGAO

1A – PROGRAMMABLE UNIJUNCTION WITH "PROGRAM" RESISTORS R1 and R2

1B – EQUIVALENT TEST CIRCUIT FOR FIGURE 1A USED FOR ELECTRICAL CHARACTERISTICS TESTING (ALSO SEE FIGURE 2)

1C – ELECTRICAL CHARACTERISTICS

FIGURE 2 – PEAK CURRENT (I_P) TEST CIRCUIT

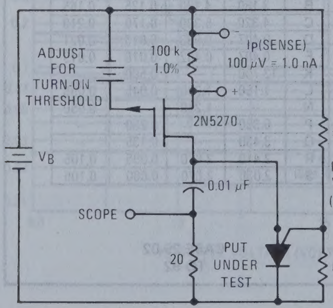
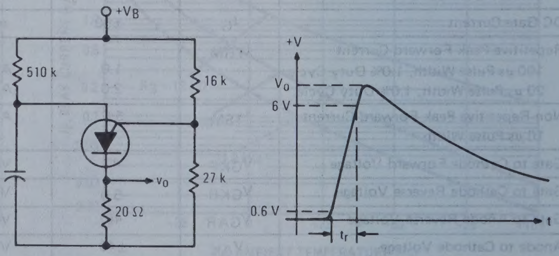

ADJUST FOR TURN-ON THRESHOLD
100 k 1.0%
–
+
Ip(SENSE) 100 µV = 1.0 nA
2N5270
VB
0.01 µF
SCOPE
20
PUT UNDER TEST
R
R
RG = R/2
VS = VB/2
(See Figure 1)

FIGURE 3 – V_o AND t_r TEST CIRCUIT


+VB
510 k
16 k
CC
vo
27 k
20 Ω
+V
Vo
6 V
0.6 V
tr
t

TYPICAL VALLEY CURRENT BEHAVIOR

FIGURE 4 – EFFECT OF SUPPLY VOLTAGE

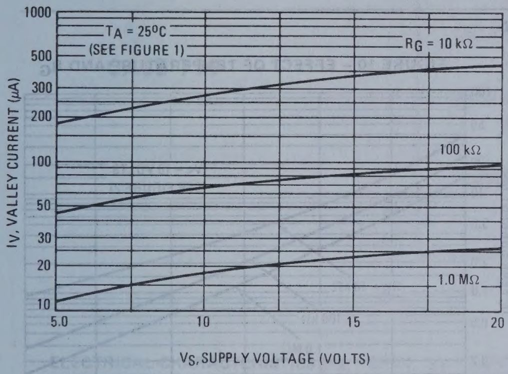


FIGURE 5 – EFFECT OF TEMPERATURE

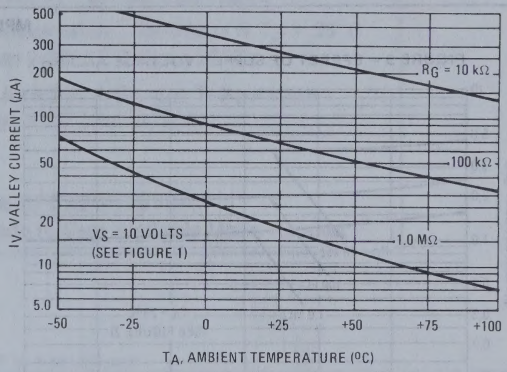


FIGURE 6 – FORWARD VOLTAGE

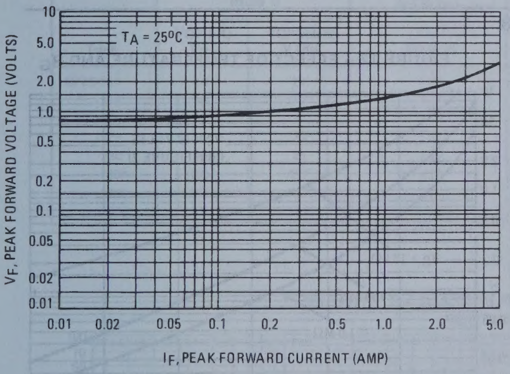


FIGURE 7 – PEAK OUTPUT VOLTAGE

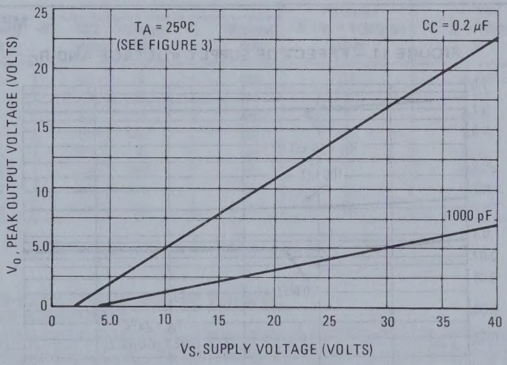
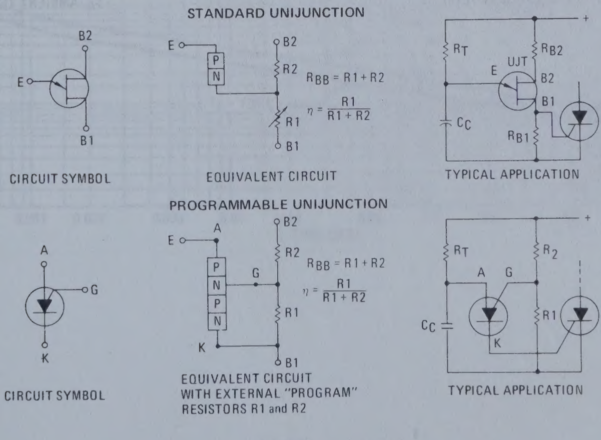


FIGURE 8 – STANDARD UNIJUNCTION
COMPARED TO PROGRAMMABLE UNIJUNCTION


STANDARD UNIJUNCTION
B2
E
B1
CIRCUIT SYMBOL
E
P
N
B2
R2
R1
B1
RBB = R1 + R2
η = R1 / (R1 + R2)
EQUIVALENT CIRCUIT
+
RT
RB2
UJT
E
B2
B1
CC
RB1
TYPICAL APPLICATION
PROGRAMMABLE UNIJUNCTION
A
G
K
CIRCUIT SYMBOL
A
E
P
N
P
N
G
K
B2
R2
R1
B1
RBB = R1 + R2
η = R1 / (R1 + R2)
EQUIVALENT CIRCUIT
WITH EXTERNAL "PROGRAM"
RESISTORS R1 and R2
+
RT
R2
A
G
CC
K
R1
TYPICAL APPLICATION

TYPICAL PEAK CURRENT BEHAVIOR

MPU6027

FIGURE 9 – EFFECT OF SUPPLY VOLTAGE AND R_G

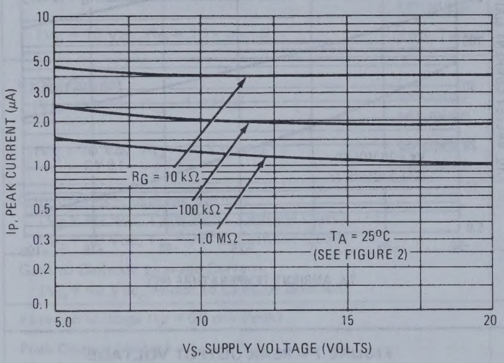
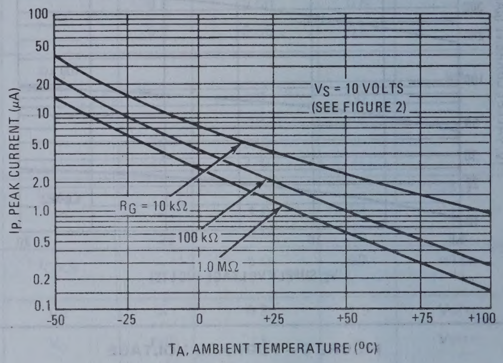


FIGURE 10 – EFFECT OF TEMPERATURE AND R_G



MPU6028

FIGURE 11 – EFFECT OF SUPPLY VOLTAGE AND R_G

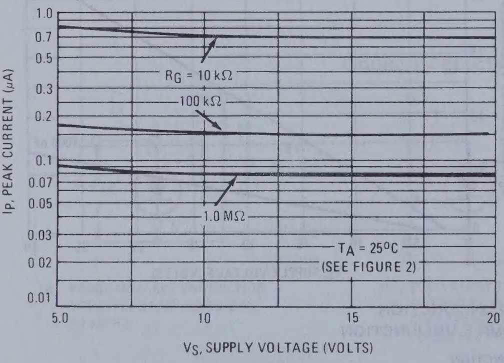
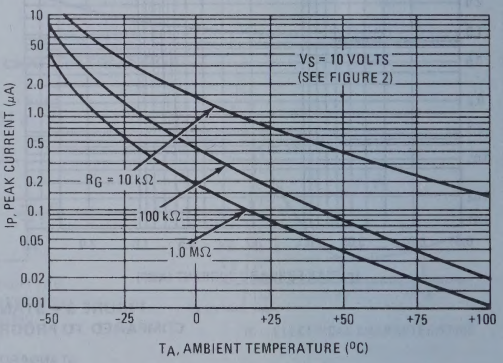
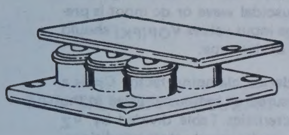


FIGURE 12 – EFFECT OF TEMPERATURE AND R_G



MPZ5-16 series (SILICON)
MPZ5-32 series
MPZ5-180 series

Silicon power transient suppressor designed for applications requiring protection of voltage sensitive electronic devices in danger of destruction by high energy voltage transients. Individual cells are matched to insure current-sharing under high current pulse conditions.



CASE 119

MAXIMUM RATINGS

Transient Power Dissipation: 40 kW
Pulse Width: 0.1 ms, (See Figure 1)

DC Power Dissipation: 350 Watts @ T_C = 25°C
(Derate 2.33 W/°C above 25°C)

Operating Junction & Storage Temperature
Range: −65°C to +175°C

Polarity:
Anode-to-Case is Standard
Cathode-to-Case Available Upon Request

ELECTRICAL CHARACTERISTICS (T_A = 25°C) (V_F = 1.5 V max @ 10 A for all types)

Type	Nominal Operating Voltage (Note 1)		Maximum Device Clamping Factor	Minimum Zener Voltage		Maximum Zener Voltage Pulse Width = 1.0 ms		Maximum Reverse Current $I_{R(max)}$ @ $V_R = V_{OP(PK)}$ µAdc	Typical Capacitance C (typ) @ $V_R = V_{OP(PK)}$ µF
	$V_{OP(PK)}$ Vdc	$V_{OP(RMS)}$ V rms	$CF = \frac{V_Z @ I_{Z(pulse)}}{V_Z @ I_{ZT}}$ (Note 2)	$V_{Z(min)}$ Vdc @	I_{ZT} Adc	$V_{Z(max)}$ Vdc @	$I_{Z(pulse)}$ Adc		
MPZ5-16A	14	10	1.25	16	0.4	24	200	50	0.025
-16B	14	10	1.25	16	0.4	20	200	↑	0.025
-32A	28	20	1.25	32	0.2	50	100		0.011
-32B	28	20	1.25	32	0.2	45	100		0.011
-32C	28	20	1.25	32	0.2	40	100		0.011
-180A	165	117	1.14	180	0.03	250	20		0.0012
-180B	165	117	1.14	180	0.03	225	20	↓	0.0012
-180C	165	117	1.14	180	0.03	205	20	50	0.0012

FIGURE 1 — MAXIMUM NON-REPETITIVE SURGE POWER
(RECTANGULAR WAVEFORM)

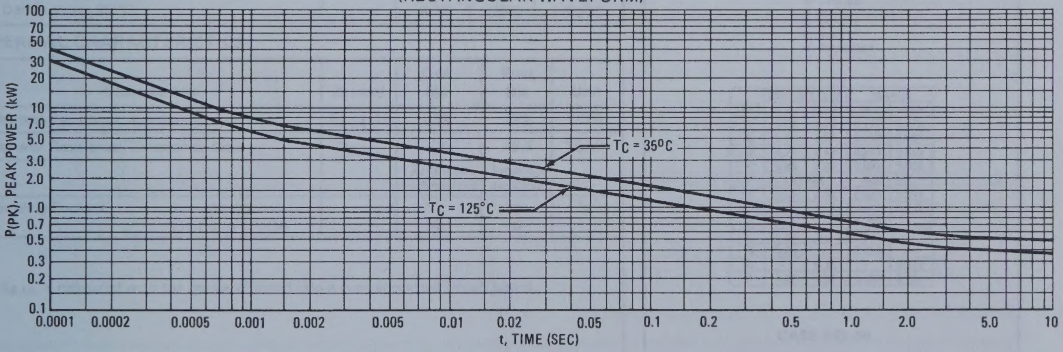
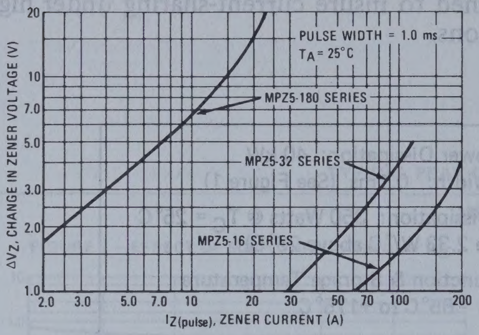


FIGURE 2 – TYPICAL DYNAMIC ZENER VOLTAGE CHARACTERISTICS (Note 2)



NOTE 1: Nominal operating voltage is defined as normal input voltage to device for non-operating condition. If non-sinusoidal wave or dc input is present, peak voltage input values $V_{OP(PK)}$ should be used to select device type.

NOTE 2: The maximum device clamping factor C_F is a ratio of V_Z measured at I_Z (pulse) given in the Electrical Characteristics Table divided by V_Z measured at I_{ZT} under steady state conditions. This value guarantees the sharpness of the voltage breakdown of individual devices. Figure 2 demonstrates the typical sharpness of the breakdown, and indicates the voltage regulation over a wide range of currents.

$$\Delta V_Z = V_Z \text{ @ } I_{Z\,(pulse)} - V_Z \text{ @ } I_{ZT}$$

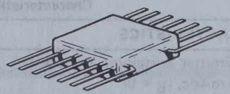
MQ930 (SILICON)
MQ2484

NPN SILICON ANNULAR MULTIPLE TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.35 Vdc (Max) @ I_C = 1.0 mAdc
- DC Current Gain Specified — 10 μAdc to 10 mAdc — MQ2484
- High Current-Gain—Bandwidth Product — f_T = 260 MHz (Typ) @ I_C = 5.0 mAdc

NPN SILICON MULTIPLE TRANSISTORS



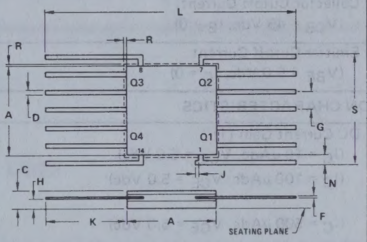
MAXIMUM RATINGS

Rating	Symbol	MQ930	MQ2484	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector-Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Die	Four Die Equal Power	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.28	600 3.42	mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.9 5.13	3.6 20.5	Watts mW/°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	Four Die	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	438	292	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	195	48.8	°C/W
		Junction to Ambient	Junction to Case	
Coupling Factors Q1-Q2 Q1-Q3 or Q1-Q4		57 55	0 0	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperatures can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of die
$R_{\theta 1 \text{ thru } 4}$ is the thermal resistance of die 1 through 4
$P_{D1 \text{ thru } 4}$ is the power dissipated in die 1 through 4
$K_{\theta 2 \text{ thru } 4}$ is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) ($I_C = 10$ mAdc, $I_B = 0$)	MQ930 MQ2484	$V_{CEO(sus)}$	45 60	– –	– –	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 45$ Vdc, $I_E = 0$)		I_{CBO}	–	–	10	nAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (1)		h_{FE}				–
($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	MQ2484		100	250	500	
($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	MQ930 MQ2484		100 175	120 120	– –	
($I_C = 500\ \mu$Adc, $V_{CE} = 5.0$ Vdc)	MQ930 MQ2484		125 200	250 250	– –	
($I_C = 1.0$ mAdc, $V_{CE} = 5.0$ Vdc)	MQ930 MQ2484		150 250	350 350	– –	
($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	Both Devices		–	260	800	
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mAdc, $I_B = 0.1$ mAdc)		$V_{CE(sat)}$	–	0.2	0.35	Vdc
Base-Emitter On Voltage ($I_C = 100\ \mu$Adc, $V_{CE} = 5.0$ Vdc)		$V_{BE(on)}$	0.5	0.58	0.7	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product ($I_C = 5.0$ mAdc, $V_{CE} = 20$ Vdc, f = 100 MHz)		f_T	–	260	–	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)		C_{ob}	–	2.7	6.0	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)	MQ2484	C_{ib}	–	2.15	6.0	pF
Noise Figure ($I_C = 10\ \mu$Adc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ k ohms, f = 10 kHz to 15.7 kHz)	MQ2484	NF	–	2.2	3.0	dB

(1) Pulse Test: Pulse Width $\leqslant 300\ \mu$s, Duty Cycle $\leqslant 2.0\%$.

MQ982 (SILICON)

For Specifications, See MD982 Data.

MQ1120 (SILICON)

For Specifications, See MD1120 Data.

MQ1129 (SILICON)

For Specifications, See MD1129 Data.

MQ2218, A (SILICON)
MQ2219, A

For Specifications, See MD2218 Data.

MQ2369 (SILICON)

For Specifications, See MD2369 Data.

MQ2904 (SILICON)
MQ2905A

For Specifications, See MD2904 Data.

MQ3251 (SILICON)

For Specifications, See MD3250 Data.

MQ3467 (SILICON)

For Specifications, See MD3467 Data.

MQ3725 (SILICON)

For Specifications, See MD3725 Data.

MQ3762 (SILICON)

For Specifications, See MD3762 Data.

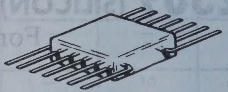
MQ3798 (SILICON)
MQ3799
MQ3799A

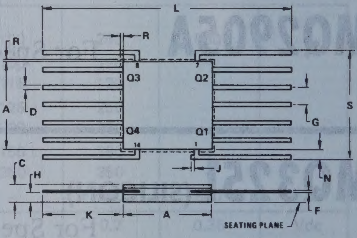
PNP SILICON ANNULAR MULTIPLE TRANSISTORS

. . . designed for use in high-gain, low noise amplifiers; front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 1.0 mAdc
- DC Current Gain Specified – 100 μAdc to 1.0 mAdc –
- High Current-Gain – Bandwidth Product – f_T = 450 MHz (Typ) @ I_C = 5.0 mAdc
- Matching Characteristics Available – MQ3799A

PNP SILICON
MULTIPLE TRANSISTORS





STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. NOT CONNECTED
5. EMITTER
6. BASE
7. COLLECTOR
8. COLLECTOR
9. BASE
10. EMITTER
11. NOT CONNECTED
12. EMITTER
13. BASE
14. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	6.99	0.240	0.275
C	0.76	2.03	0.030	0.080
D	0.25	0.48	0.010	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	0.13	0.89	0.005	0.035
J	–	0.38	–	0.015
K	6.35	–	0.250	–
L	18.80	–	0.740	–
N	0.25	–	0.010	–
R	–	0.38	–	0.015
S	7.62	8.38	0.300	0.330

CASE 607-04

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector-Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC
		One Die	All Die Equal Power	
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.28	600 3.42	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	0.7 4.0	2.8 16	Watts mW/^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	One Die	All Die Equal Power	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	438	292	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	250	62.6	$^oC/W$
		Junction to Ambient	Junction to Case	
Coupling Factors Q1-Q2 Q1-Q3 or Q1-Q4		57 55	0 0	%

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices, coupling of heat between die occurs. The junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of die 1
$R_{\theta 1}$ thru 4 is the thermal resistance of die 1 through 4
P_{D1} thru 4 is the power dissipation in die 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between die 1 and die 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_D$, equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4}) /4$$

Values for the coupling factors when either the case or the ambient is used as a reference are given in the table on page 1.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)		$V_{CEO(sus)}$	60	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	10	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MQ3798		150	200	450	
	MQ3799,A		300	375	900	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MQ3798		150	250	450	
	MQ3799,A		300	400	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MQ3798		150	260	450	
	MQ3799,A		300	400	900	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				
(I_C = 100 μAdc, I_B = 10 μAdc)			–	0.08	0.2	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			–	0.08	0.25	
Base Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			–	0.65	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			–	0.68	0.8	
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.64	0.7	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	–	450	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.1	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	5.5	8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms) f = 10 kHz to 15.7 kHz)		NF	–	2.0	–	dB
MATCHING CHARACTERISTICS (2) MQ3799A						
DC Current Gain Ration (3) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		h_{FE}/h_{FE}	0.9	–	1.0	–
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc,)		V_{BE1}-V_{BE2}	–	–	3.0	mVdc
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +125°C)		$\dfrac{\Delta \lvert V_{BE1}-V_{BE2}}{\Delta T}$	–	–	10	μV/°C

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.
(2) Matching characteristics are guaranteed between any two of the four transistors.
(3) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

DC CURRENT GAIN

(— V_{CE} = 5.0 Vdc, - - - V_{CE} = 10 Vdc)

FIGURE 1 – MQ3798

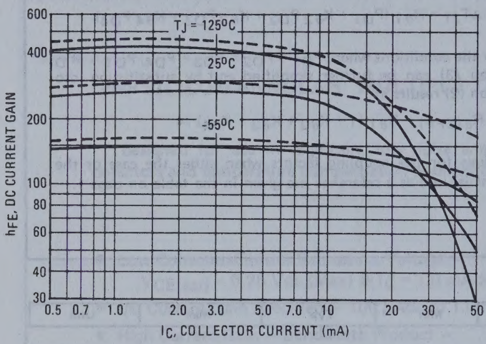


FIGURE 2 – MQ3799, MQ3799A

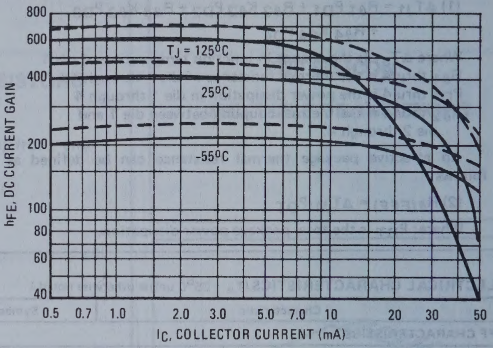


FIGURE 3 – "ON" VOLTAGES

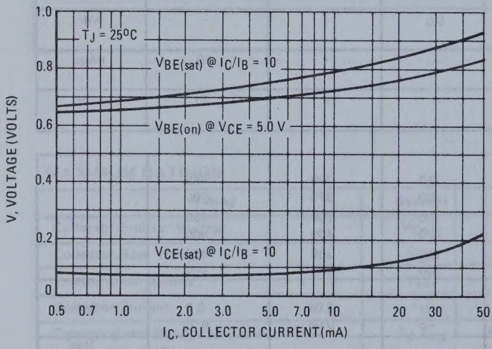


FIGURE 4 – BASE-EMITTER TEMPERATURE COEFFICIENT

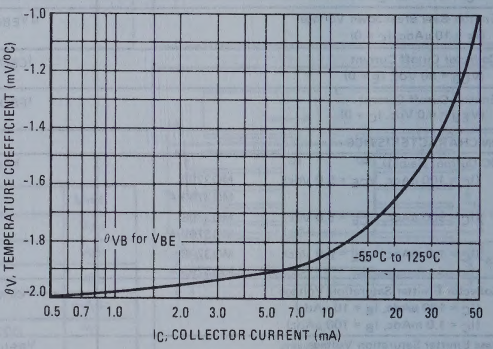


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

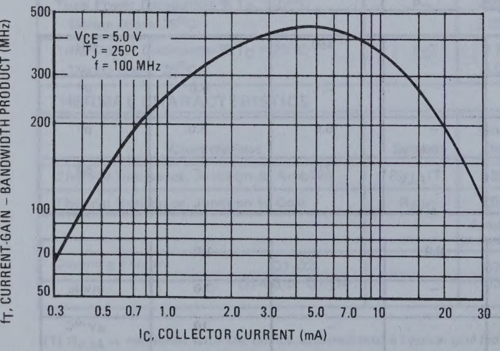
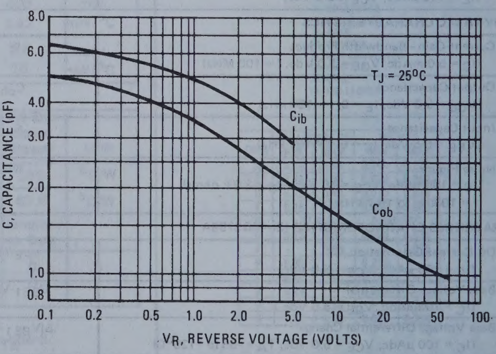


FIGURE 6 – CAPACITANCE



MQ6001 (SILICON)
MQ6002

For Specifications, See MD6001 Data.

MQ7001 (SILICON)

For Specifications, See MD7001 Data.

MQ7003 (SILICON)

For Specifications, See MD7003 Data.

MQ7004 (SILICON)

For Specifications, See MD7004 Data.

MQ7007 (SILICON)

For Specifications, See MD7007 Data.

MQ7021 (SILICON)

For Specifications, See MD7021 Data.

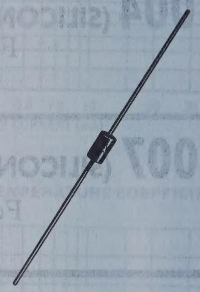
MR1-1200 (SILICON)
MR1-1400
MR1-1600

AXIAL LEAD SILICON RECTIFIERS

. . . designed for television "damper" diode service and other high voltage industrial/consumer applications.

- High Current Handling — 1.0 Ampere at 75°C
- Medium Recovery Characteristics
- Low Forward Voltage

HIGH VOLTAGE
LEAD MOUNTED
SILICON RECTIFIERS
1200, 1400, 1600, VOLTS
1 AMPERE



MAXIMUM RATINGS

Rating	Symbol	MR1-1200	MR1-1400	MR1-1600	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	1200	1400	1600	Volts
Average Rectified Forward Current (Single phase, resistive load, $R_{\theta JA}$ = 85°C/W, T_A = 75°C) (1)	I_O	1.0			Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions.)	I_{FSM}	30 (for 1 cycle)			Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	-65 to +175			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage	v_F			Volts
(i_F = 1.0 Amp, T_J = 25°C)		0.95	1.1	
(i_F = 3.14 Amp, T_J = 25°C)		1.1	1.3	
Maximum Reverse Current (rated dc voltage)	I_R			μA
T_J = 25°C		0.2	10	
T_J = 100°C		12	100	
Capacitance (V_R = 50 volts, f = 1.0 MHz)	C	4.0	7.0	pF
Reverse Recovery Time (I_F = 20 mA, I_R = 2.0 mA)	t_{rr}	17	25	μs
Forward Recovery Time (I_F = 20 mA, V_{fr} = 2.0 V)	t_{fr}	0.7	1.0	μs

(1) Must be derated for reverse power dissipation. See note on Page 3.

(2) Derate as shown in Figure 4.

MECHANICAL CHARACTERISTICS

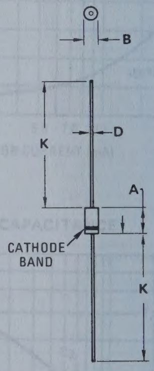
CASE: Void free, Transfer Molded

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 seconds at 5 lbs. tension

FINISH: All external surfaces are corrosion-resistant, leads are readily solderable

POLARITY: Cathode indicated by color band

WEIGHT: 0.40 Grams (approximately)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.70	5.20	0.185	0.205
B	2.54	2.71	0.100	0.107
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-01
CONFORMS TO DO-41

FIGURE 1 – FORWARD POWER DISSIPATION

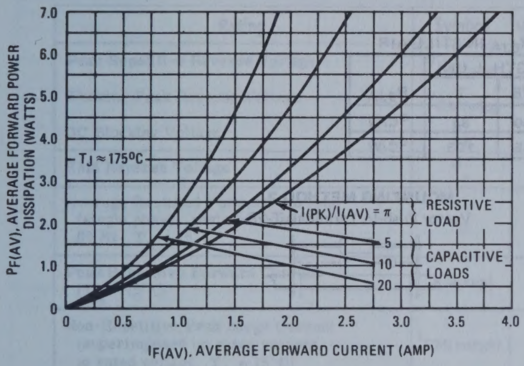


FIGURE 2 – CURRENT DERATING

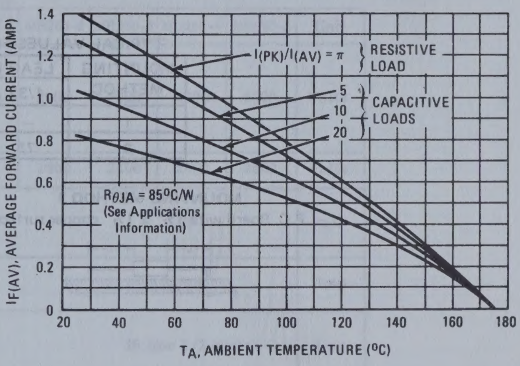


FIGURE 3 – NON-REPETITIVE SURGE CURRENT

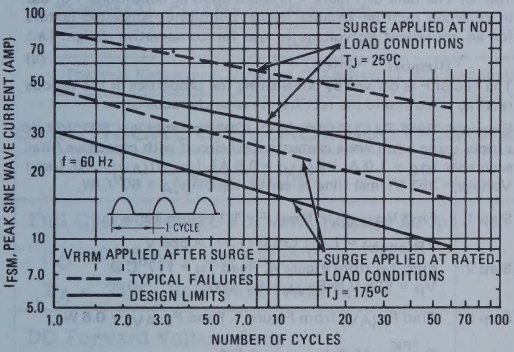
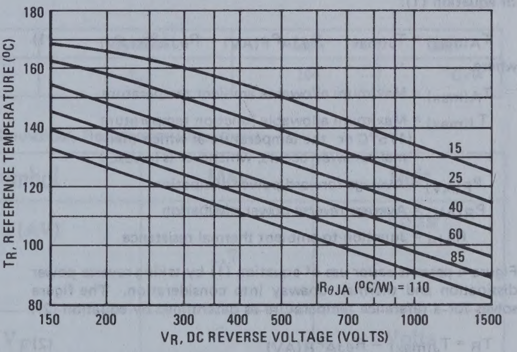


FIGURE 4 – MAXIMUM REFERENCE TEMPERATURE



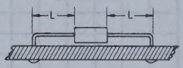
APPLICATIONS INFORMATION

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)			$R_{\theta JA}$
	1/32	3/8	1	
1	–	60	85	°C/W
2	73	85	103	°C/W

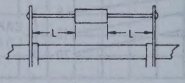
MOUNTING METHOD 1

P.C. Board with 1½" x 1½" copper surface



MOUNTING METHOD 2

Vector Push-In Terminals T-28



Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 50 volts. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \qquad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (175°C or the temperature at which thermal runaway occurs, whichever is lowest.)

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figure 4 permits easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figure solves for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \qquad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \qquad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 175°C when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figure 4 as a difference in the rate of change of the slope in the vicinity of 160°C. The data of Figure 4 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design: i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \qquad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the rectifiers reverse characteristics.

Example: Find $T_{A(max)}$ for MR1-1200 operated in a 500 Volt dc supply using a full wave center-tapped circuit with capacitive filter such that I_{DC} = 1.0 A, ($I_{F(AV)}$ = 0.5 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 353 V(rms) (line to center tap), $R_{\theta JA}$ = 60°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 1.11 from Table 1.
$V_{R(equiv)}$ = 1.41) (353) (1.11) = 555 V

Step 2: Find T_R from Figure 4. Read T_R = 117°C @ V_R = 555 V @ $R_{\theta JA}$ = 60°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 1. Read $P_{F(AV)}$ = 0.6 W @ $\frac{I_{PK}}{I_{AV}}$ = 10 & $I_{F(AV)}$ = 0.5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 117 -(60) (0.6) = 81°C.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave Center-Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.45	1.11	0.45	0.55	0.90	1.11
Square Wave	0.61	1.22	0.61	0.61	1.22	1.22

*Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$ †Use line to center tap voltage for V_{in}

MR250-1 thru MR250-5

High-voltage, low-current rectifiers designed for applications where high-voltages in subminiature packages are required.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	MR250-1	MR250-2	MR250-3	MR250-4	MR250-5	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	1000	2000	3000	4000	5000	Volts
RMS Reverse Voltage	V_r	700	1400	2100	2800	3500	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_A = 75°C)	I_O	250					mA
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	2.0					Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C)	$I_{FM(surge)}$	15 (for 1/2 cycle)					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150					°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1 inch lead length)	θ_{JA}	100	°C/W

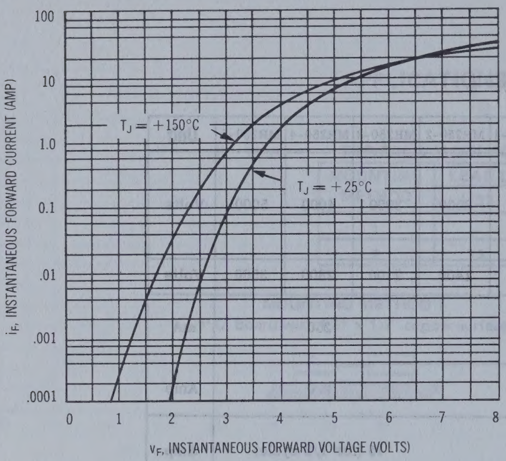
ELECTRICAL CHARACTERISTICS (At 60 Hz Sinusoidal, Resistive or Inductive)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 0.25 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	1.7	Volts
DC Forward Voltage Drop (I_F = 0.25 Adc, T_A = 25°C)	V_F	3.5	Volts
Full Cycle Average Reverse Current (I_O = 0.25 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$I_{R(AV)}$	100	μA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	10	μA

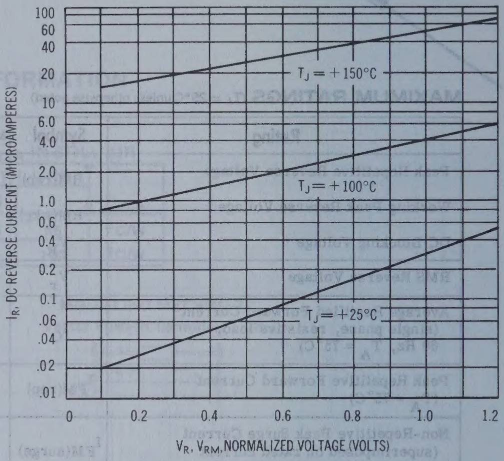
MECHANICAL CHARACTERISTICS

CASE: Void free, flame-proof silicone polymer case
FINISH: All external surfaces corrosion-resistant and leads readily solderable
POLARITY: Indicated by polarity band
MOUNTING POSITIONS: Any
WEIGHT: 0.40 Gram (approx)
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8″ from case for 10 seconds

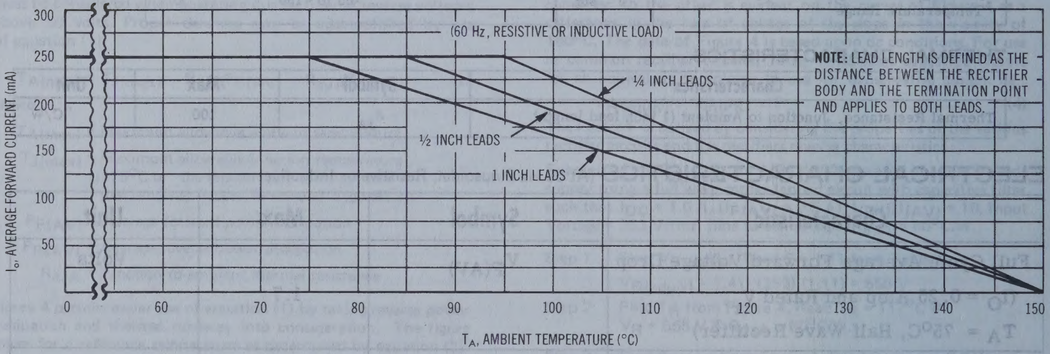
TYPICAL FORWARD CHARACTERISTICS



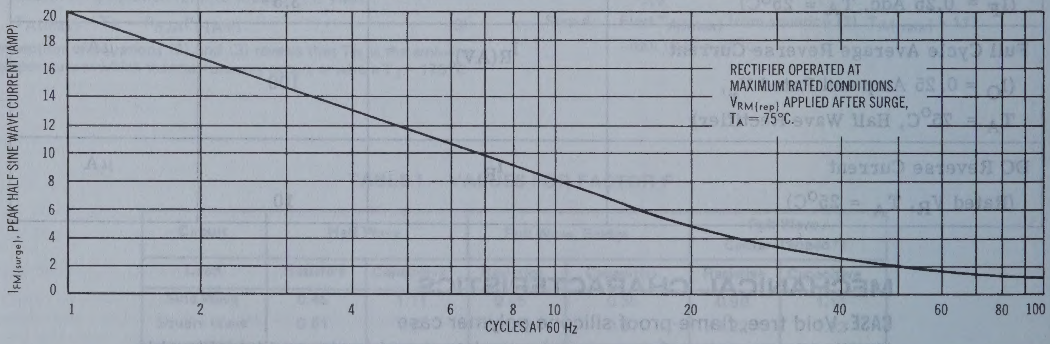
TYPICAL REVERSE CHARACTERISTICS



CURRENT DERATING



MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT



MR327, MR328, MR330, MR331

For Specifications, See 1N3491 Data, Volume 1.

MR501, MR502, MR504
MR506, MR508, MR510

Designers Data Sheet

MINIATURE SIZE, AXIAL LEAD MOUNTED STANDARD RECOVERY POWER RECTIFIERS

. . . designed for use in power supplies and other applications having need of a device with the following features:

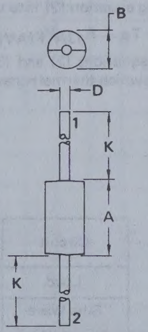
- High Current to Small Size
- High Surge Current Capability
- Low Forward Voltage Drop
- Void-Free Economical Plastic Package
- Available in Volume Quantities

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

STANDARD RECOVERY POWER RECTIFIERS

100-1000 VOLTS
3 AMPERE



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

CASE 267-01

MAXIMUM RATINGS

Rating	Symbol	MR 501	MR 502	MR 504	MR 506	MR 508	MR 510	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	150	250	450	650	850	1050	Volts
Average Rectified Forward Current (Single phase resistive load, T_A = 95°C, PC Board Mounting) (1)	I_O	← 3.0 →						Amp
(EIA Standard Conditions L = 1/32", T_L = 85°C)		← 8.0 →						
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 100 → (one cycle)						Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	← −65 to +175 →						°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mounting, See Note 2 on Page 4).	$R_{\theta JA}$	28	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (3)	v_F				Volts
(i_F = 9.4 Amp, T_J = 175°C)		–	0.9	1.0	
(i_F = 9.4 Amp, T_J = 25°C)		–	1.04	1.1	
Reverse Current (rated dc voltage) (3)	I_R				μA
T_J = 25°C		–	0.1	5.0	
T_J = 100°C		–	2.8	25	

(1) Derate for reverse power dissipation. See Note on Page 2.
(2) Derate as shown in Figure 1.
(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

Case: Void Free, Transfer Molded
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Indicated by Cathode Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8" from case for 10 s at 5.0 lb. tension

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 200 volts. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \qquad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (175°C or the temperature at which thermal runaway occurs, whichever is lowest.)

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figure 1 permits easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figure solves for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \qquad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \qquad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 175°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figure 1 as a difference in the rate of change of the slope in the vicinity of 165°C. The data of Figure 1 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \qquad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the rectifiers reverse characteristics.

Example: Find $T_{A(max)}$ for MR510 operated in a 400 Volt dc supply using a full wave center-tapped circuit with capacitive filter such that I_{DC} = 6.0 A, ($I_{F(AV)}$ = 3.0 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 283 V(rms) (line to center tap), $R_{\theta JA}$ = 28°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 1.11 from Table 1 ∴

$V_{R(equiv)}$ = 1.41)(283)(1.11) = 444 V

Step 2: Find T_R from Figure 1. Read T_R = 167°C @ V_R = 444 V & $R_{\theta JA}$ = 28°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 8. Read $P_{F(AV)}$ = 4 W @ $\frac{I_{PK}}{I_{AV}}$ = 10 & $I_{F(AV)}$ = 3.0 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 167-(28)(4) = 55°C.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave Center-Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.45	1.11	0.45	0.55	0.90	1.11
Square Wave	0.61	1.22	0.61	0.61	1.22	1.22

*Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$

†Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE

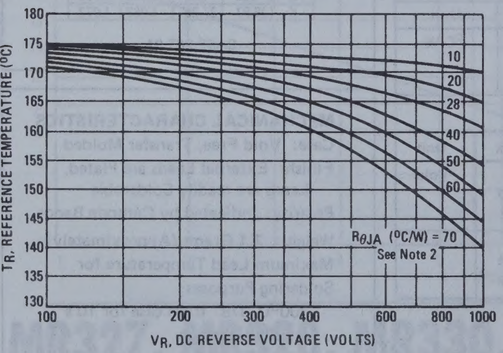
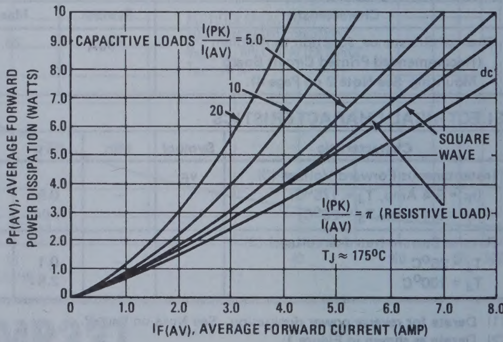


FIGURE 2 – FORWARD POWER DISSIPATION



CURRENT DERATING
(Reverse Power Loss Neglected)

FIGURE 3 – PC BOARD MOUNTING

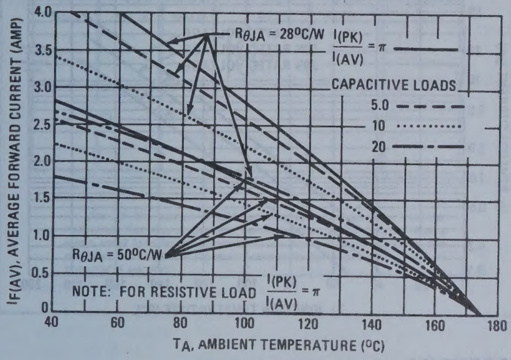


FIGURE 4 – SEVERAL LEAD LENGTHS

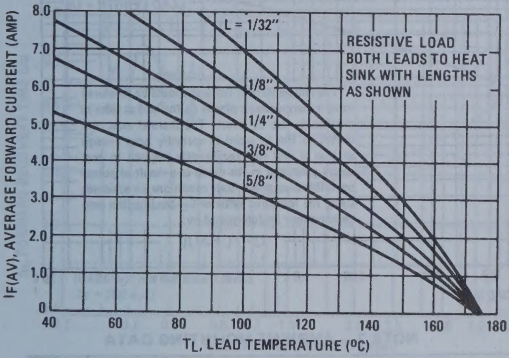


FIGURE 5 – 1/8″ LEAD LENGTH

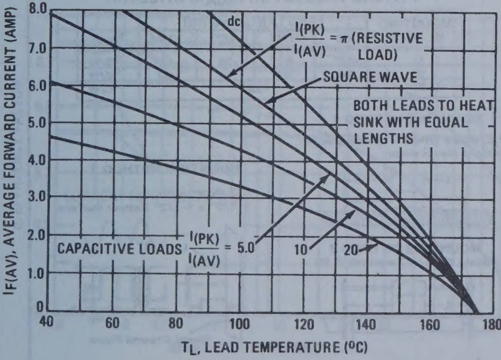


FIGURE 6 – FORWARD VOLTAGE

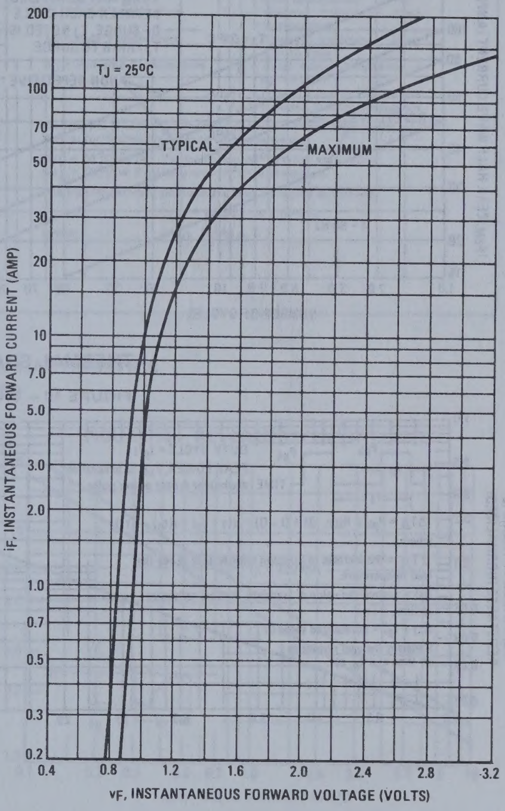


FIGURE 7 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

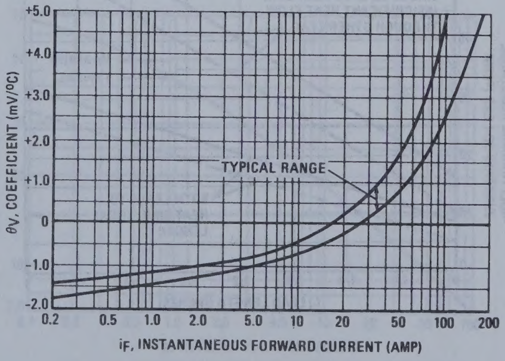


FIGURE 8 – MAXIMUM SURGE CAPABILITY

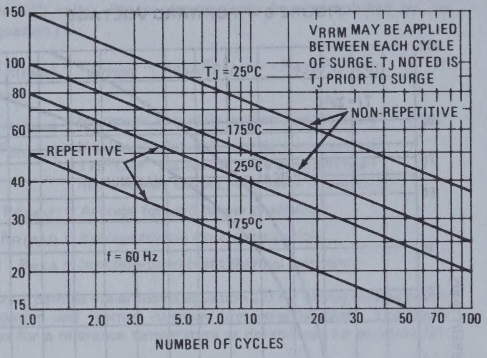
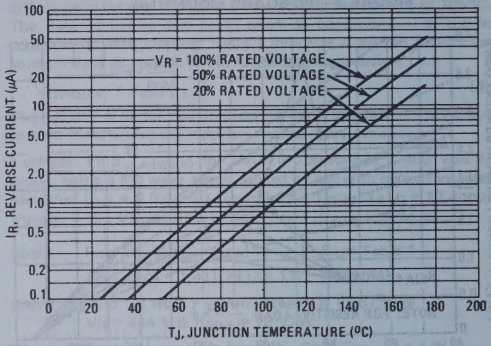
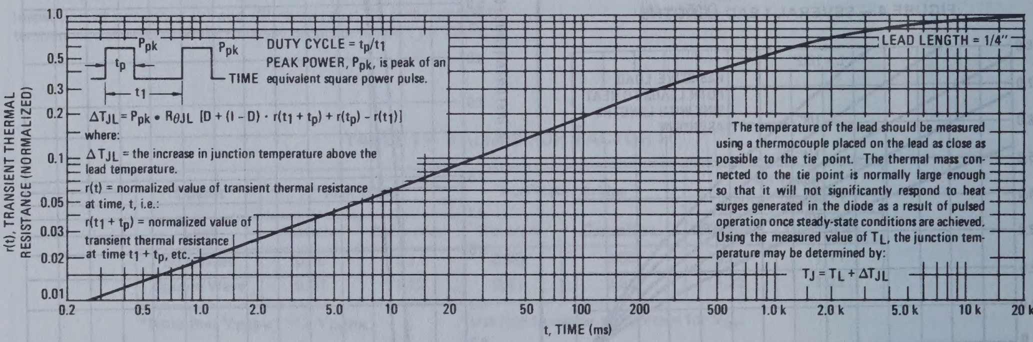


FIGURE 9 – TYPICAL REVERSE CURRENT



THERMAL CHARACTERISTICS

FIGURE 10 – THERMAL RESPONSE



DUTY CYCLE = t_p/t_1

PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

$\Delta T_{JL} = P_{pk} \bullet R_{\theta JL}\ [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$

where:

ΔT_{JL} = the increase in junction temperature above the lead temperature.

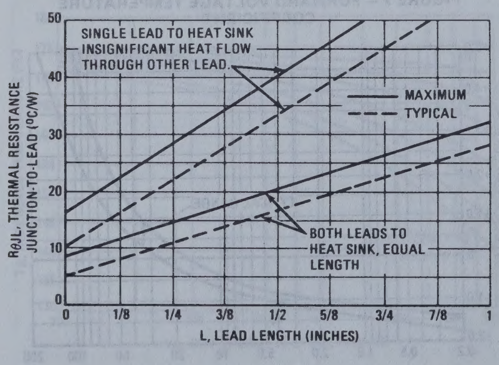
r(t) = normalized value of transient thermal resistance at time, t, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$, etc.

The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

$T_J = T_L + \Delta T_{JL}$

FIGURE 11 – STEADY-STATE THERMAL RESISTANCE



NOTE 2 – AMBIENT MOUNTING DATA

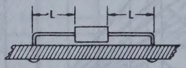
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

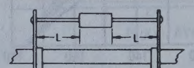
MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.



MOUNTING METHOD 2

Vector Push-In Terminals T-28



MOUNTING METHOD 3

P.C. Board with 1-1/2″ x 1-1/2″ Copper Surface

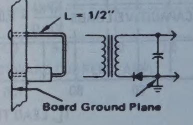
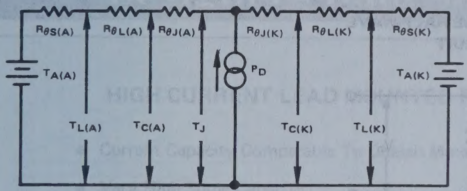


FIGURE 12 – APPROXIMATE THERMAL CIRCUIT MODEL

THERMAL CIRCUIT MODEL
(For Heat Conduction Through the Leads)



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Total Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts (A) and (K) refer to anode and cathode sides respectively.)
Values for thermal resistance components are:

$R_{\theta L}$ = 46°C/W/IN. Typically and 48°C/W/IN Maximum.
$R_{\theta J}$ = 10°C/W Typically and 16°C/W Maximum.

The maximum lead temperature may be found as follows:

$$T_L = T_{J(max)} - \Delta T_{JL} \bullet P_D$$

where $\Delta T_{JL} \approx R_{\theta JL}$

TYPICAL DYNAMIC CHARACTERISTICS

(T_J = 25°C)

FIGURE 13 – FORWARD RECOVERY TIME

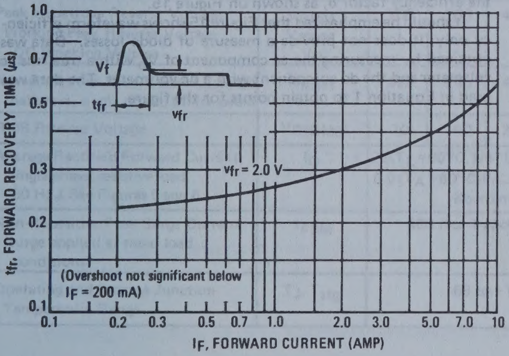


FIGURE 14 – REVERSE RECOVERY TIME

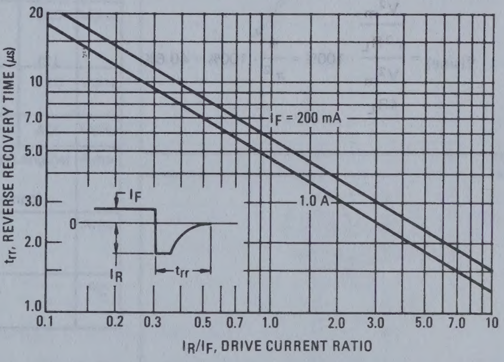


FIGURE 15 – RECTIFICATION WAVEFORM EFFICIENCY

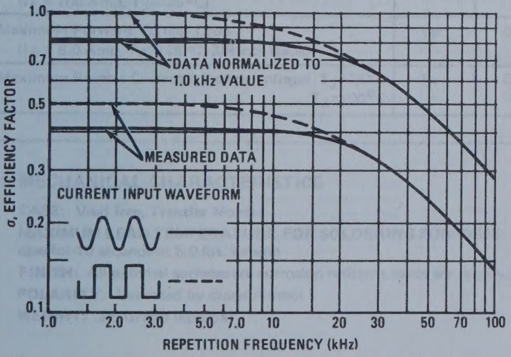
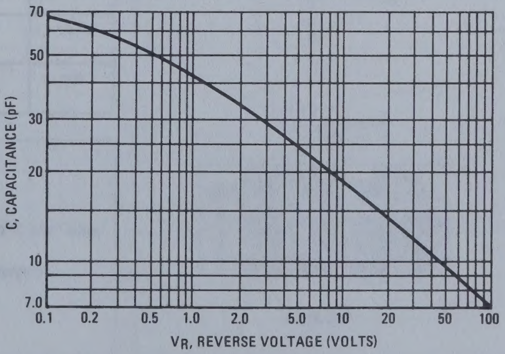
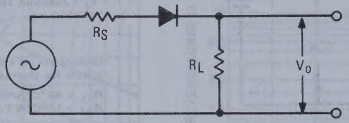


FIGURE 16 – JUNCTION CAPACITANCE



RECTIFIER EFFICIENCY NOTE

FIGURE 17 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 15 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\dfrac{V^2{}_{o(dc)}}{R_L}}{\dfrac{V^2{}_{o(rms)}}{R_L}} \cdot 100\% = \frac{V^2{}_{o(dc)}}{V^2{}_{o(ac)} + V^2{}_{o(dc)}} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\dfrac{V^2{}_m}{\pi^2 R_L}}{\dfrac{V^2{}_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\dfrac{V^2{}_m}{2R_L}}{\dfrac{V^2{}_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 14) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 15.

It should be emphasized that Figure 15 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for the figure.

MR751 (SILICON)
MR752
MR754
MR756

Designers Data Sheet

HIGH CURRENT LEAD MOUNTED RECTIFIERS

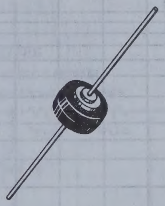
- Current Capacity Comparable To Chassis Mounted Rectifiers
- Very High Surge Capacity
- Insulated Case

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

HIGH CURRENT
LEAD MOUNTED
SILICON RECTIFIERS

100–600 VOLTS
DIFFUSED JUNCTION



MAXIMUM RATINGS

Characteristic	Symbol	MR751	MR752	MR754	MR756	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz peak)	V_{RSM}	120	240	480	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	70	140	280	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz.) See Figures 5 and 6	I_O	22($T_L = 60^oC$, 1/8" Lead Lengths) 6.0($T_A = 60^oC$, P.C. Board mounting)				Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	400 (for 1 cycle)				Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175				^oC

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop ($I_F = 100$ Amp, $T_J = 25^oC$)	v_F	1.25	Volts
Maximum Forward Voltage Drop ($I_F = 6.0$ Amp, $T_A = 25^oC$, 3/8 inch leads)	V_F	0.90	Volts
Maximum Reverse Current (rated dc voltage) $T_J = 25^oC$ $T_J = 100^oC$	I_R	0.25 1.0	mA

MECHANICAL CHARACTERISTICS

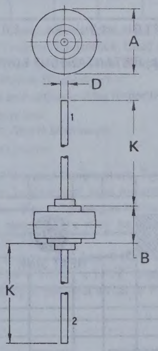
CASE: Void free, Transfer Molded

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C 3/8" from case for 10 seconds at 5.0 lbs. tension

FINISH: All external surfaces are corrosion-resistant, leads are readily solderable

POLARITY: Indicated by diode symbol

WEIGHT: 2.5 Grams (approx)



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.03	10.29	0.395	0.405
B	5.94	6.25	0.234	0.246
D	1.27	1.35	0.050	0.053
K	25.15	25.65	0.990	1.010

CASE 194

FIGURE 1 – FORWARD VOLTAGE

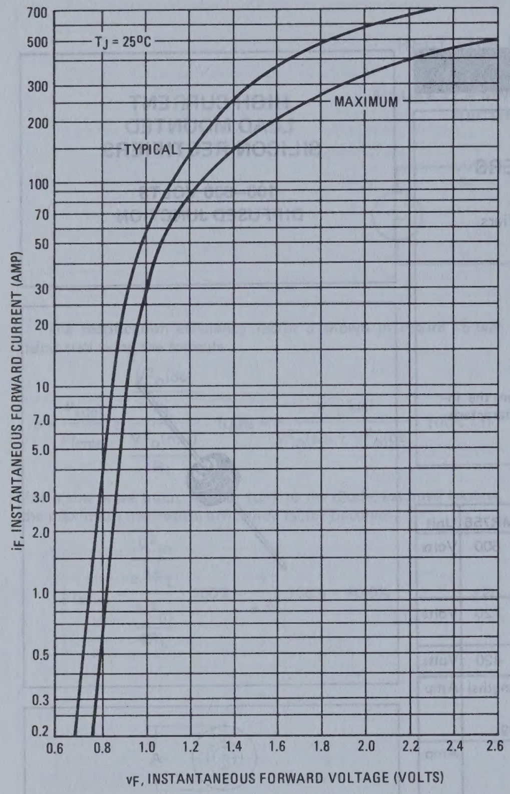


FIGURE 2 – MAXIMUM SURGE CAPABILITY

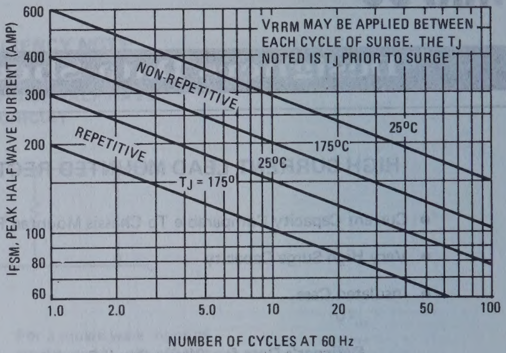


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

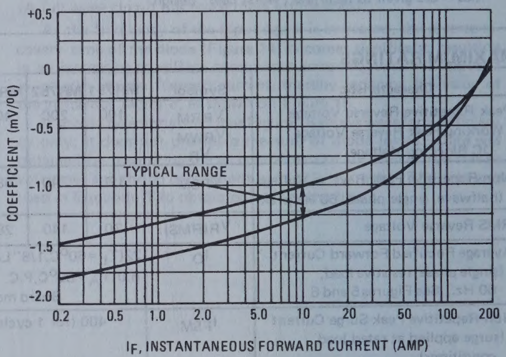
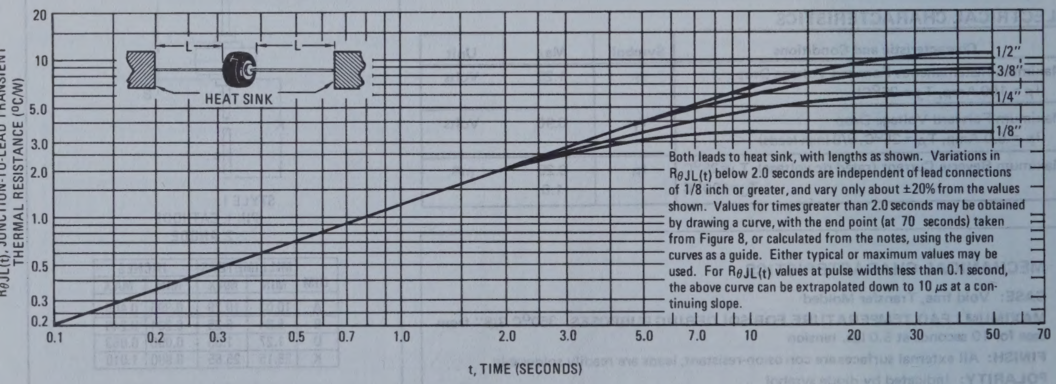


FIGURE 4 – TYPICAL TRANSIENT THERMAL RESISTANCE



Both leads to heat sink, with lengths as shown. Variations in $R_{\theta JL}(t)$ below 2.0 seconds are independent of lead connections of 1/8 inch or greater, and vary only about ±20% from the values shown. Values for times greater than 2.0 seconds may be obtained by drawing a curve, with the end point (at 70 seconds) taken from Figure 8, or calculated from the notes, using the given curves as a guide. Either typical or maximum values may be used. For $R_{\theta JL}(t)$ values at pulse widths less than 0.1 second, the above curve can be extrapolated down to 10 μs at a continuing slope.

FIGURE 5 – MAXIMUM CURRENT RATINGS

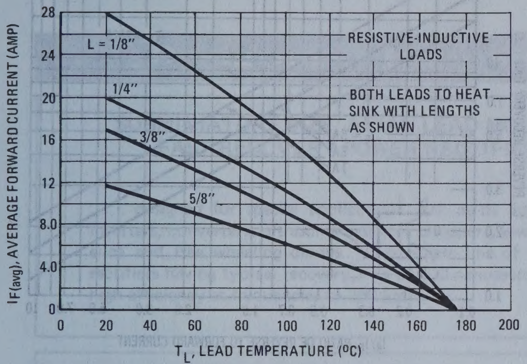


FIGURE 6 – MAXIMUM CURRENT RATINGS

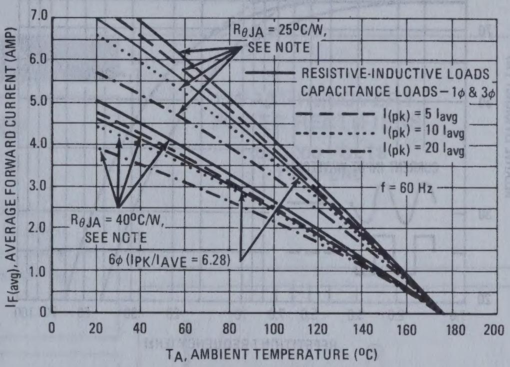


FIGURE 7 – POWER DISSIPATION

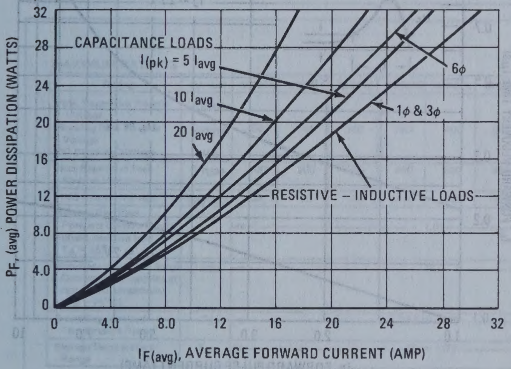
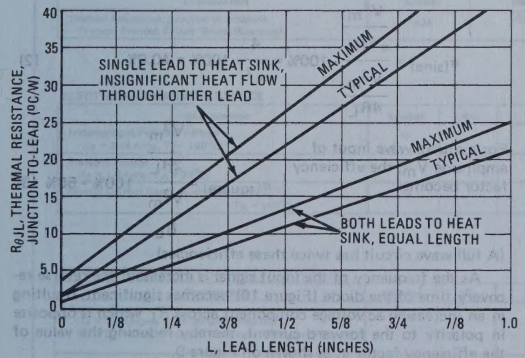


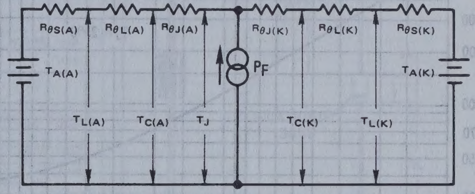
FIGURE 8 – STEADY STATE THERMAL RESISTANCE



NOTES

THERMAL CIRCUIT MODEL

(For Heat Conduction Through The Leads)



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. Lowest values occur when one side of the rectifier is brought as close as possible to the heat sink as shown below. Terms in the model signify:

T_A = Ambient Temperature	$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
T_L = Lead Temperature	$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
T_C = Case Temperature	$R_{\theta J}$ = Thermal Resistance, Junction to Case
T_J = Junction Temperature	P_F = Power Dissipation

(Subscripts (A) and (K) refer to anode and cathode sides respectively.)

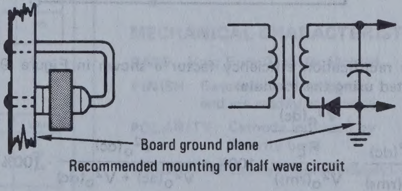
Values for thermal resistance components are:

$R_{\theta L}$ = 40°C/W/IN. Typically and 44°C/W/IN Maximum

$R_{\theta J}$ = 2°C/W Typically and 4°C/W Maximum

Since $R_{\theta J}$ is so low, measurements of the case temperature, T_C, will be approximately equal to junction temperature in practical lead mounted applications. When used as a 60 Hz rectifier, the slow thermal response holds $T_{J(PK)}$ close to $T_{J(AVG)}$. Therefore maximum lead temperature may be found from: $T_L = 175° - R_{\theta JL} P_F$. P_F may be found from Figure 7.

The recommended method of mounting to a P.C. board is shown on the sketch, where $R_{\theta JA}$ is approximately 25°C/W for a 1-1/2″ x 1-1/2″ copper surface area. Values of 40°C/W are typical for mounting to terminal strips or P.C. boards where available surface area is small.



Recommended mounting for half wave circuit

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 9 – RECTIFICATION EFFICIENCY

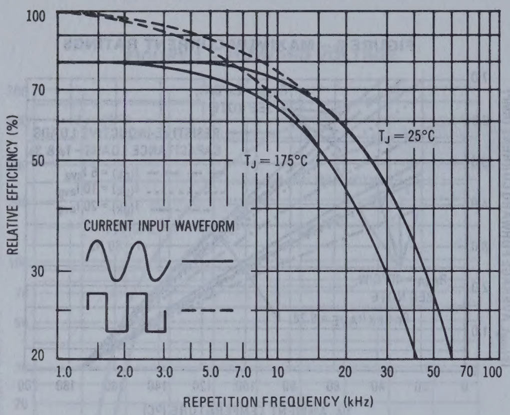


FIGURE 10 – REVERSE RECOVERY TIME

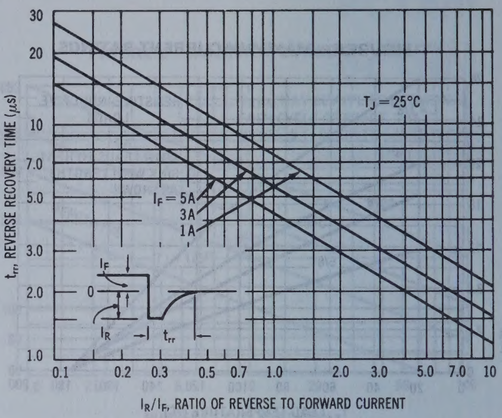


FIGURE 11 – JUNCTION CAPACITANCE

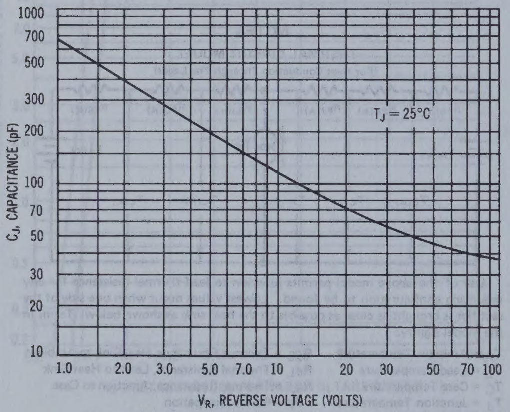


FIGURE 12 – FORWARD RECOVERY TIME

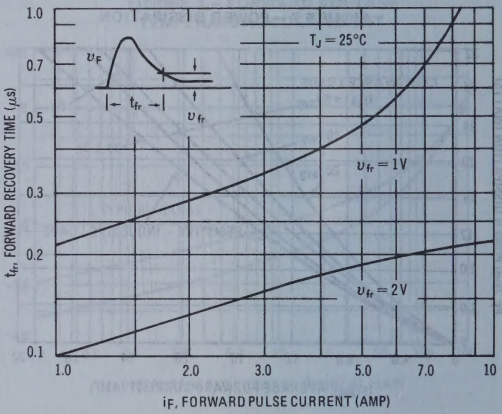
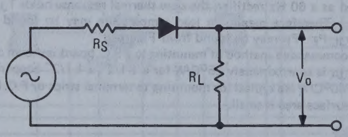


FIGURE 13 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 9 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\dfrac{V^2{}_o(dc)}{R_L}}{\dfrac{V^2{}_o(rms)}{R_L}} \cdot 100\% = \frac{V^2{}_o(dc)}{V^2{}_o(ac) + V^2{}_o(dc)} \cdot 100\% \qquad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\dfrac{V^2{}_m}{\pi^2 R_L}}{\dfrac{V^2{}_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \qquad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\dfrac{V^2{}_m}{2R_L}}{\dfrac{V^2{}_m}{R_L}} \cdot 100\% = 50\% \qquad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 10) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 9.

It should be emphasized that Figure 9 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 9.

MR810 thru MR814
MR816 thru MR818

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 200 nanoseconds providing high efficiency at frequencies to 250 kHz.

DESIGNER'S DATA FOR "WORST CASE" CONDITIONS

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing device characteristic boundaries — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR810	MR811	MR812	MR813	MR814	MR816	MR817	MR818	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	100	200	300	400	500	800	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	560	700	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_A = 75^oC$)	I_O	← 1.0 →								Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions) ($T_A = 75^oC$)	I_{FSM}	← 30 →								Amps
Operating Junction Temperature Range	T_J	← -65 to +150 →								^oC
Storage Temperature Range	T_{stg}	← -65 to +175 →								^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Typical Primted Circuit Board Mounting)	$R_{\theta JA}$	65	$^oC/W$

ELECTRICAL CHARACTERISTICS

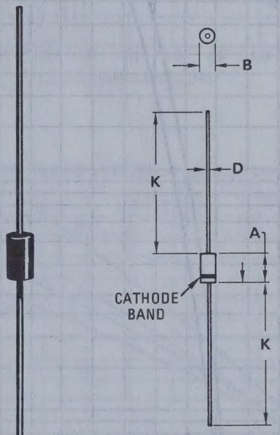
Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 3.14$ Amp, $T_J = 150^oC$)	v_F	–	1.1	1.2	Volts
Forward Voltage ($I_F = 1.0$ Amp, $T_A = 25^oC$)	V_F	–	1.0	1.1	Volts
Reverse Current (rated dc voltage) $T_A = 25^oC$ $T_A = 100^oC$	I_R	– –	1.0 50	10 100	μA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc) (Figure 21) ($I_F = 20$ mA, $I_R = 2.0$ mA, Tektronix S-Plug-In) (Figure 22)	t_{rr}	– –	200 1.0	750 3.0	ns μs
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc) (Figure 21)	$I_{RM(REC)}$	–	–	3.0	Amp

FAST RECOVERY POWER RECTIFIERS

50-1000 VOLTS
1 AMPERE



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.70	5.20	0.185	0.205
B	2.54	2.71	0.100	0.107
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-01

CONFORMS TO DO-41

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded

FINISH: External leads are plated and are readily solderable

POLARITY: Cathode indicated by Polarity band

WEIGHT: 0.4 Grams (Approximately)

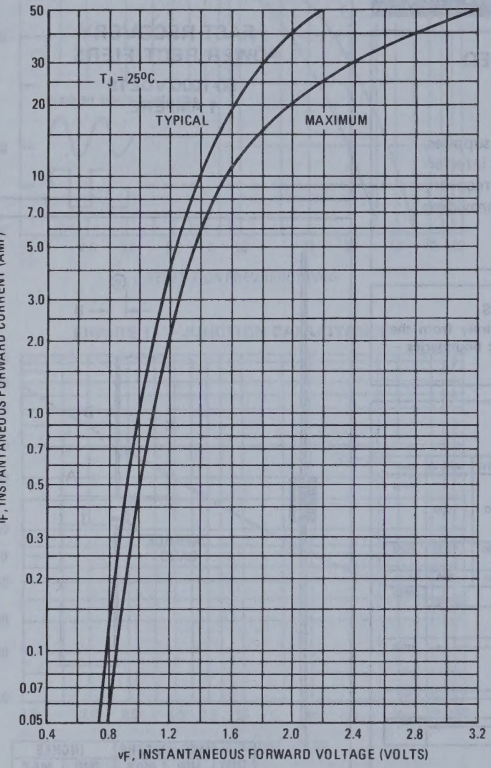


FIGURE 1 – FORWARD VOLTAGE

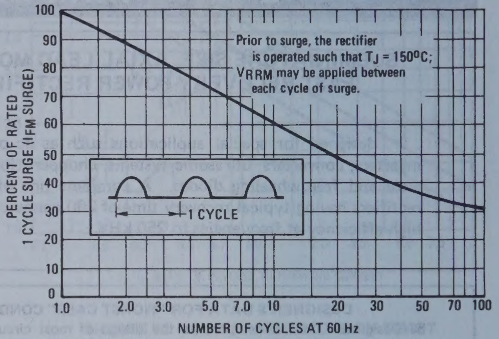


FIGURE 2 – MAXIMUM SURGE CAPABILITY

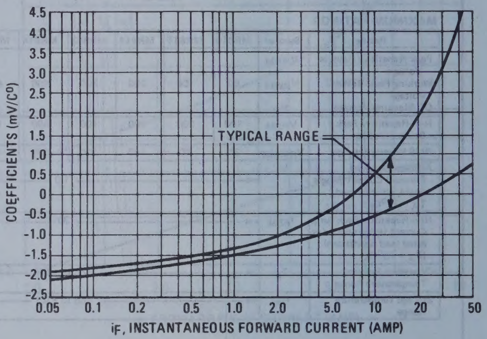


FIGURE 3 – TEMPERATURE COEFFICIENT

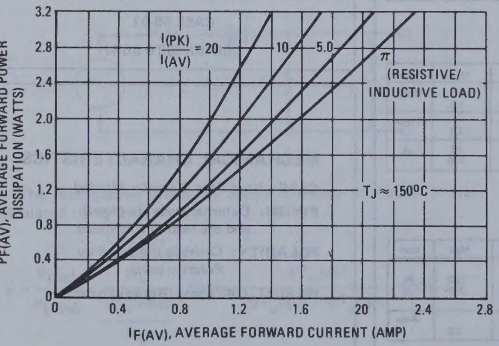


FIGURE 4 – FORWARD POWER DISSIPATION

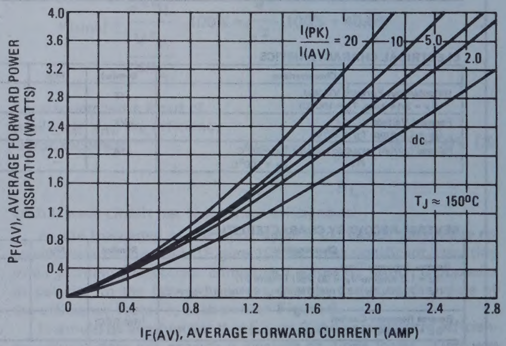


FIGURE 5 – FORWARD POWER DISSIPATION

MAXIMUM CURRENT RATINGS

(SEE NOTES 1 and 2)

SINE WAVE INPUT

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

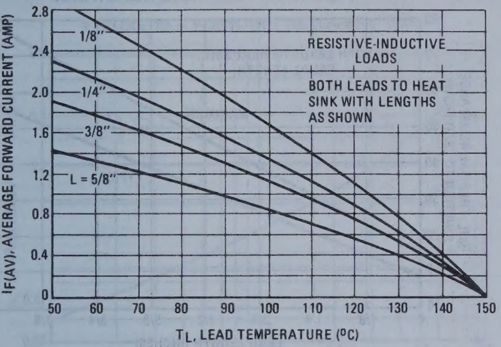


FIGURE 8 – 1/8″ LEAD LENGTH, VARIOUS LOADS

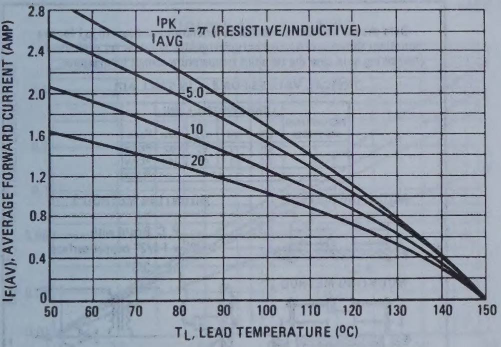
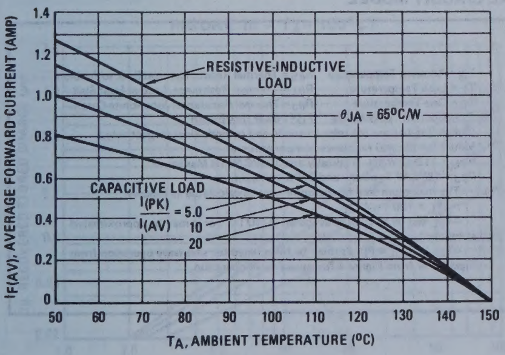


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUT

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

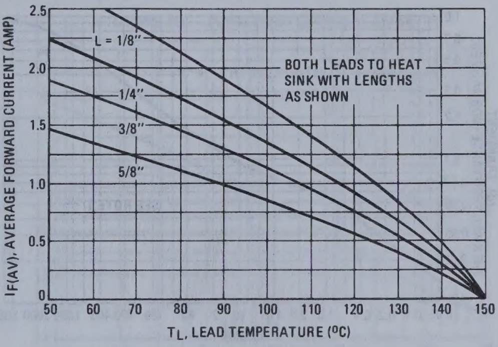


FIGURE 9 – 1/8″ LEAD LENGTH, VARIOUS LOADS

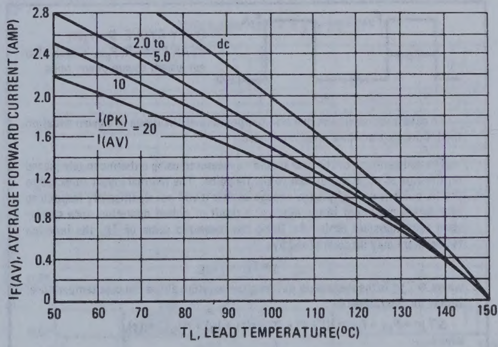


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

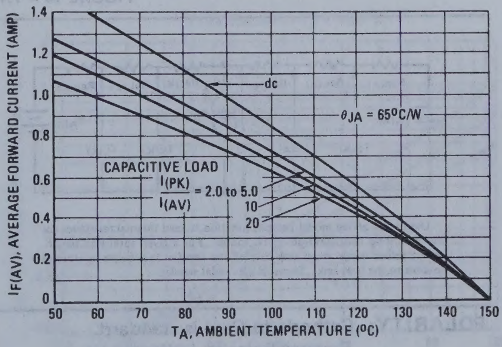


FIGURE 12 – THERMAL RESPONSE

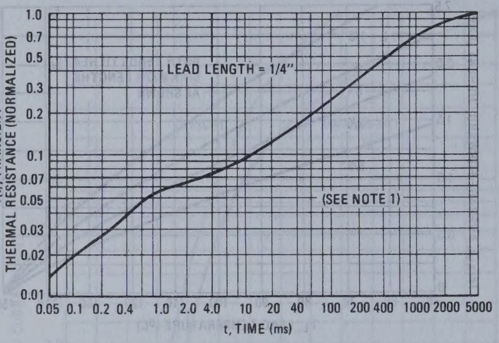
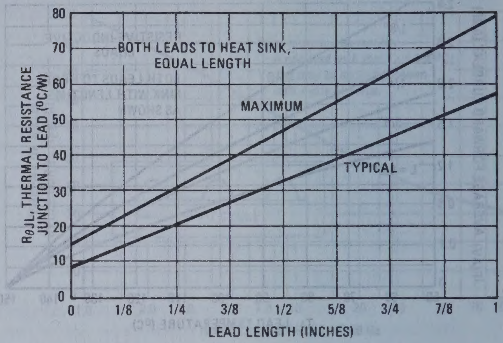
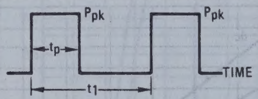


FIGURE 13 – THERMAL RESISTANCE



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} \left[D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)\right]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 12, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

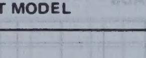
NOTE 2

Data shown for thermal resistance junction-to-ambient (θ_{JA}) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

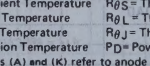
TYPICAL VALUES FOR θ_{JA} IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	65	72	82	92	°C/W
2	74	81	91	101	°C/W
3	40				°C/W

MOUNTING METHOD 1



MOUNTING METHOD 2



Vector pin mounting

MOUNTING METHOD 3

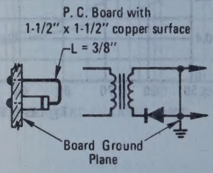
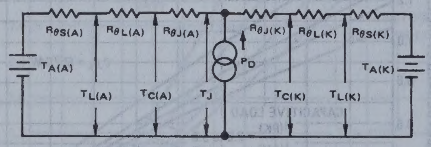


FIGURE 14 – THERMAL CIRCUIT MODEL



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Power Dissipation

(Subscripts (A) and (K) refer to anode and cathode sides respectively.)

Values for thermal resistance components are:

$R_{\theta L}$ = 112°C/W/IN. Typically and 128°C/W/IN Maximum
$R_{\theta J}$ = 18°C/W Typically and 30°C/W Maximum

The maximum lead temperature may be calculated as follows:

$$T_L = 150^\circ - \Delta T_{JL}$$

ΔT_{JL} can be calculated as shown in NOTE 1 or it may be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \bullet P_F$; P_F may be formulated for sine-wave operation from Figure 3 or from Figure 4 for square-wave operation.

POLARITY: Cathode to Case is standard.
Reverse Polarity indicated by
an "R" suffix, i.e., MR871R.

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 15 – FORWARD RECOVERY TIME

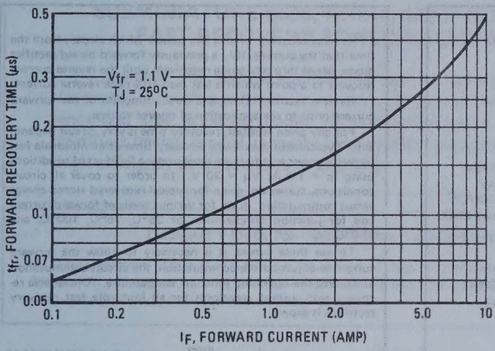
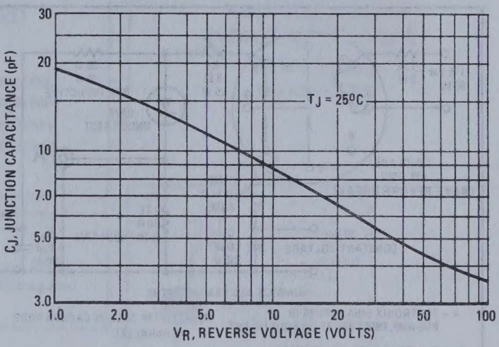


FIGURE 16 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(SEE NOTE 3)

FIGURE 17 – T_J = 25°C

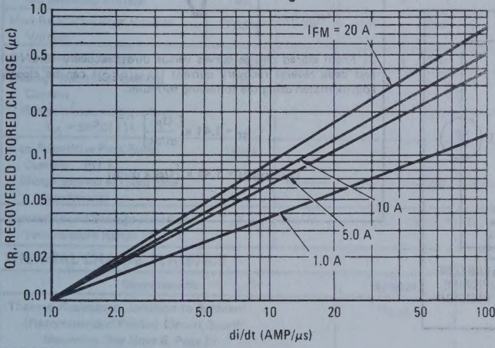


FIGURE 18 – T_J = 75°C

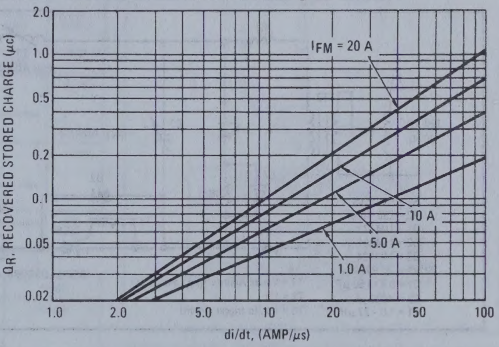


FIGURE 19 – T_J = 100°C

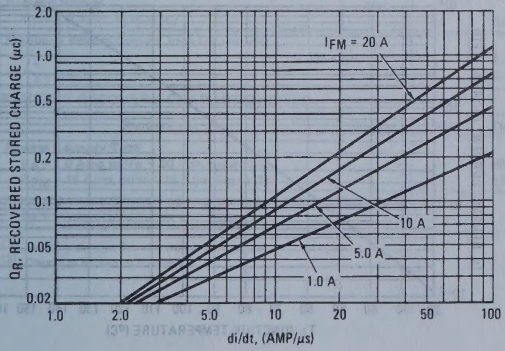


FIGURE 20 – T_J = 150°C

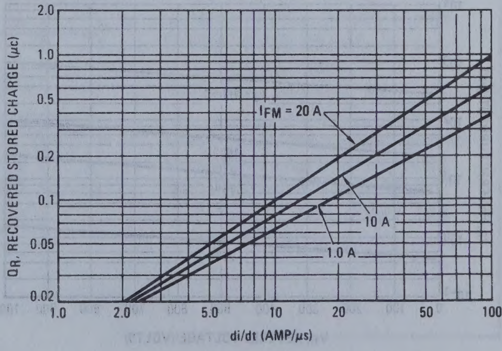
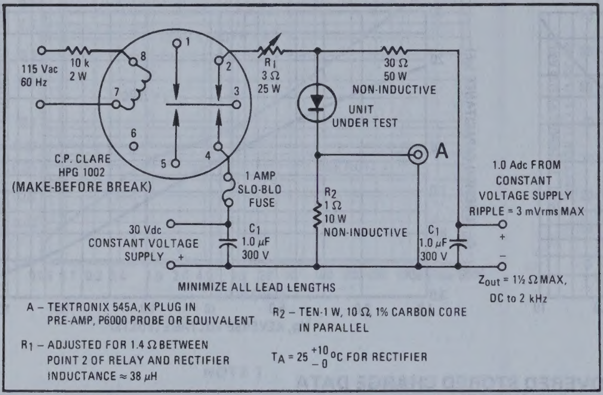


FIGURE 21 – REVERSE RECOVERY CIRCUIT


115 Vac
60 Hz
10 k
2 W
1
2
3
4
5
6
7
8
C.P. CLARE
HPG 1002
(MAKE-BEFORE BREAK)
R_1
3 Ω
25 W
30 Ω
50 W
NON-INDUCTIVE
UNIT
UNDER TEST
A
1 AMP
SLO-BLO
FUSE
R_2
1 Ω
10 W
NON-INDUCTIVE
1.0 Adc FROM
CONSTANT
VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
30 Vdc
CONSTANT VOLTAGE
SUPPLY
C_1
1.0 μF
300 V
C_1
1.0 μF
300 V
+
–
Z_{out} = 1½ Ω MAX,
DC to 2 kHz
MINIMIZE ALL LEAD LENGTHS
A – TEKTRONIX 545A, K PLUG IN
PRE-AMP, P6000 PROBE OR EQUIVALENT
R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE
IN PARALLEL
R_1 – ADJUSTED FOR 1.4 Ω BETWEEN
POINT 2 OF RELAY AND RECTIFIER
INDUCTANCE ≈ 38 μH
$T_A = 25\ ^{+10}_{-0}$ °C FOR RECTIFIER

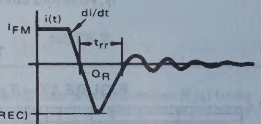
NOTE 3

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.


I_{FM}
i(t)
di/dt
t_{rr}
Q_R
$I_{RM(REC)}$

From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

FIGURE 22 – JEDEC REVERSE RECOVERY CIRCUIT

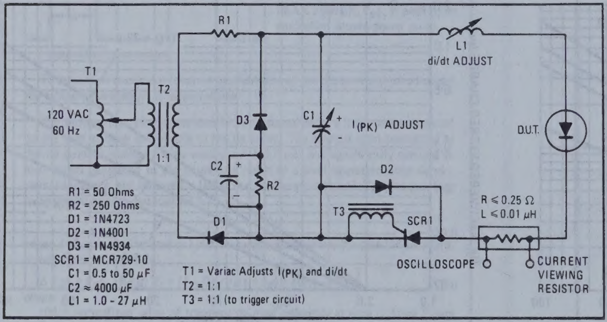

R1
L1
di/dt ADJUST
T1
T2
120 VAC
60 Hz
1:1
D3
C1
+
–
$I_{(PK)}$ ADJUST
D.U.T.
C2
+
–
R2
D2
T3
SCR1
D1
R ≤ 0.25 Ω
L ≤ 0.01 μH
OSCILLOSCOPE
CURRENT
VIEWING
RESISTOR
R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4934
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1:1
T3 = 1:1 (to trigger circuit)

FIGURE 23 – TYPICAL REVERSE LEAKAGE

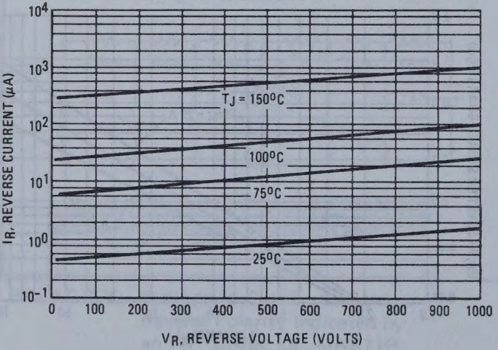
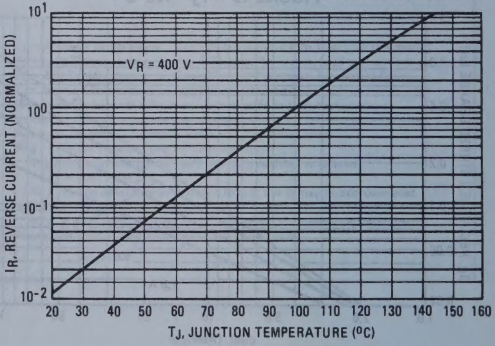


FIGURE 24 – TYPICAL REVERSE LEAKAGE



MR820,MR821,MR822, MR824,MR826

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

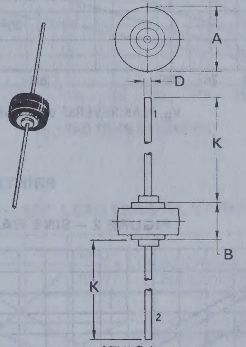
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
5.0 AMPERES



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.03	10.29	0.395	0.405
B	5.94	6.25	0.234	0.246
D	1.27	1.35	0.050	0.053
K	25.15	25.65	0.990	1.010

CASE 194

MAXIMUM RATINGS

Rating	Symbol	MR820	MR821	MR822	MR824	MR826	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_A = 55^oC$) (1)	I_O	← 5.0 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 300 →					Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	← -65 to +175 →					^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mounting, See Note 6, Page 8)	$R_{\theta JA}$	25	$^oC/W$

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 15.7$ Amp, $T_J = 150^oC$)	v_F	–	0.75	1.05	Volts
Forward Voltage ($I_F = 5.0$ Amp, $T_J = 25^oC$)	V_F	–	0.9	1.0	Volts
Maximum Reverse Current, (rated dc voltage) $T_J = 25^oC$ $T_J = 100^oC$	I_R	 – –	 5.0 0.5	 25 1.0	 μA mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 25) ($I_{FM} = 15$ Amp, di/dt = 25 A/μs, Figure 26)	t_{rr}	 – –	 100 150	 200 300	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 25)	$I_{RM(REC)}$	–	–	2.0	Amp

(1) Must be derated for reverse power dissipation. See Note 3

(2) Derate as shown in Figure 1.

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded

FINISH: External Surfaces are Corrosion Resistant

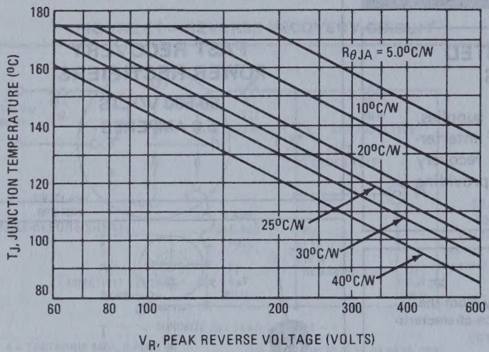
POLARITY: Indicated by Diode Symbol

WEIGHT: 2.5 Grams (Approximately)

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 s at 5.0 lb. tension.

MAXIMUM CURRENT AND TEMPERATURE RATINGS

FIGURE 1 – MAXIMUM ALLOWABLE JUNCTION TEMPERATURE



NOTE 1
MAXIMUM JUNCTION TEMPERATURE DERATING

When operating this rectifier at junction temperatures over approximately 85°C, reverse power dissipation and the possibility of thermal runaway must be considered. The data of Figure 1 is based upon worst case reverse power and should be used to derate $T_{J(max)}$ from its maximum value of 175°C. See Note 3 for additional information on derating for reverse power dissipation.

When current ratings are computed from $T_{J(max)}$ and reverse power dissipation is also included, ratings vary with reverse voltage as shown on Figures 2 thru 5.

RESISTIVE LOAD RATINGS

PRINTED CIRCUIT BOARD MOUNTING – SEE NOTE 6, PAGE 8

FIGURE 2 – SINE WAVE INPUT

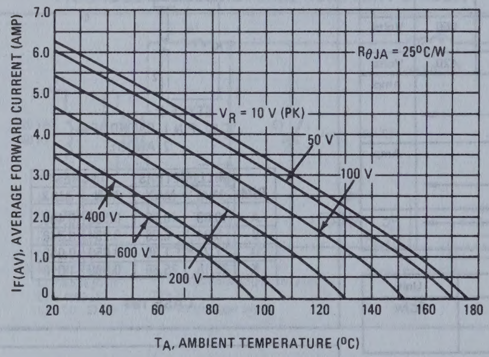


FIGURE 3 – SQUARE WAVE INPUT

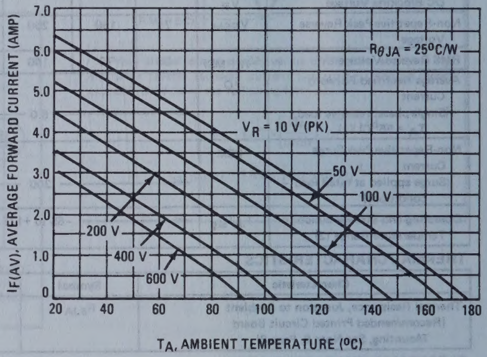


FIGURE 4 – SINE WAVE INPUT

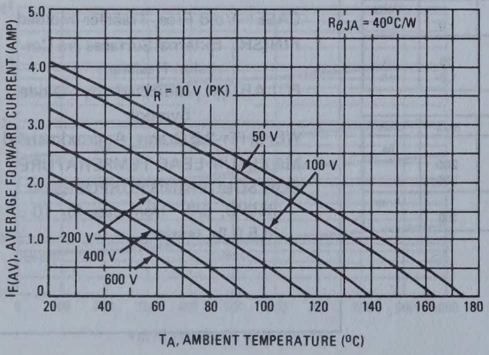
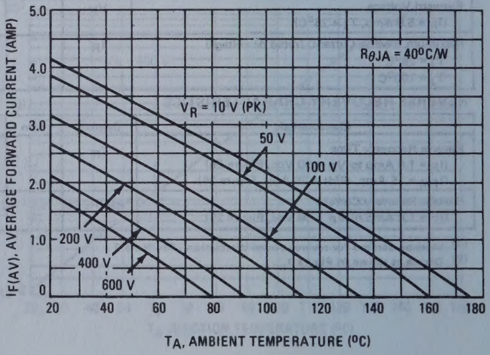


FIGURE 5 – SQUARE WAVE INPUT



MAXIMUM CURRENT RATINGS

NOTE 2

Current derating data is based upon the thermal response data of Figure 29 and the forward power dissipation data of Figures 19 and 20. Since reverse power dissipation is not considered in Figures 6 thru 11, additional derating for reverse voltage and for junction to ambient thermal resistance must be applied. See Note 3.

SINE WAVE INPUT

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

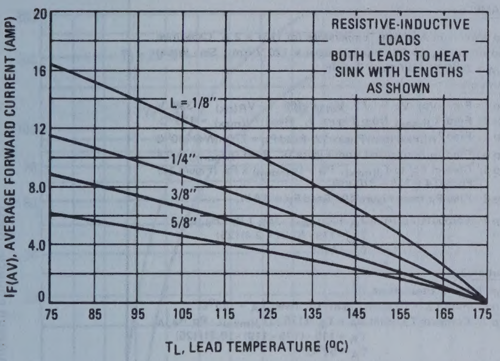


FIGURE 8 – 1/8″ LEAD LENGTH, VARIOUS LOADS

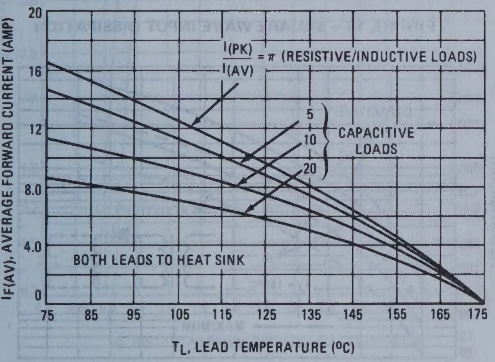
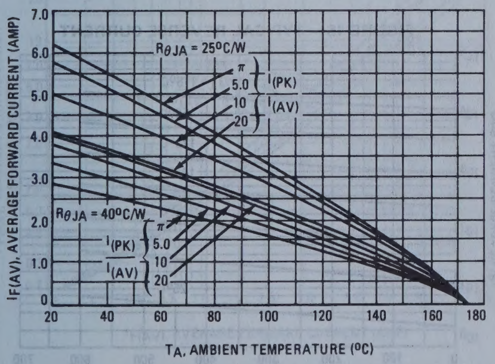


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUT

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

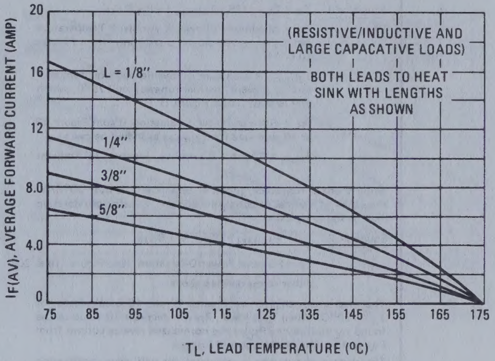


FIGURE 9 – 1/8″ LEAD LENGTH, VARIOUS LOADS

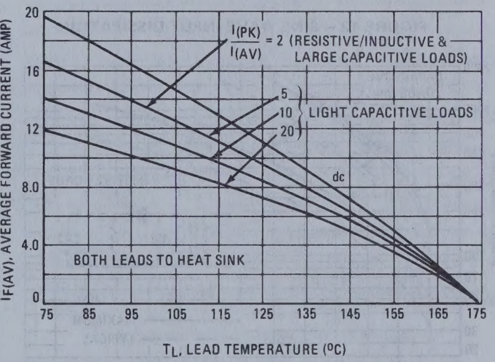
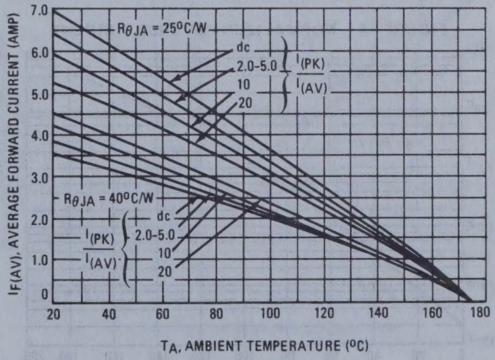


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



REVERSE POWER DISSIPATION AND CURRENT

NOTE 3
DERATING FOR REVERSE POWER DISSIPATION

In this rectifier, power loss due to reverse current is generally not negligible. For reliable circuit design, the maximum junction temperature must be limited to either 175°C or the temperature which results in thermal runaway. Proper derating may be accomplished by use of equation 1 or equation 2.

Equation 1 $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$

Where: T_1 = Maximum Allowable Ambient Temperature neglecting reverse power dissipation (from Figures 10 or 11)

$T_{J(max)}$ = Maximum Allowable Junction Temperature to prevent thermal runaway or 175°C, which ever is lower. (See Figure 1).

P_R = Reverse Power Dissipation (From Figure 12 or 13, adjusted for $T_{J(max)}$ as shown below)

$R_{\theta JA}$ = Thermal Resistance, Junction to Ambient.

When thermal resistance, junction to ambient, is over 20°C/W, the effect of thermal response is negligible. Satisfactory derating may be found by using:

Equation 2 $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$

P_F = Forward Power Dissipation (See Figures 19 & 20)

Other terms defined above.

The reverse power given on Figures 12 and 13 is calculated for $T_J = 150^{\circ}C$. When T_J is lower, P_R will decrease; its value can be found by multiplying P_R by the normalized reverse current from Figure 14 at the temperature of interest.

The reverse power data is calculated for half wave rectification circuits. For full wave rectification using either a bridge or a center-tapped transformer, the data for resistive loads is equivalent when V_P is the line to line voltage across the rectifiers. For capacitive loads, it is recommended that the dc case on Figure 13 be used, regardless of input waveform, for bridge circuits. For capacitively loaded full wave center-tapped circuits, the 20:1 data of Figure 12 should be used for sine wave inputs and the capacitive load data of Figure 13 should be used for square wave inputs regardless of $I_{(pk)}/I_{(av)}$. For these two cases, V_P is the voltage across one leg of the transformer.

EXAMPLE:

Find Maximum Ambient Temperature for I_{AV} = 2 A, Capacitive Load of $I_{PK}/I_{AV} = 20$, Input Voltage = 120 V (rms) Sine Wave, $R_{\theta JA} = 25^{\circ}C/W$, Half Wave Circuit.

Solution 1:

Step 1: Find V_P; $V_P = \sqrt{2}\, V_{in} = 169$ V, $V_{R(pk)} = 338$ V
Step 2: Find $T_{J(max)}$ from Figure 1. Read $T_{J(max)} = 119^{\circ}C$.
Step 3: Find $P_{R(max)}$ from Figure 12. Read P_R = 770 mW @ 140°C
Step 4: Find I_R normalized from Figure 14. Read $I_{R(norm)} = 0.4$
Step 5: Correct P_R to $T_{J(max)}$. $P_R = I_{R(norm)} \times P_R$ (Figure 12)
$P_R = 0.4 \times 770 = 310$ mW.
Step 6: Find P_F from Figure 19. Read P_F = 2.4 W.
Step 7: Compute T_A from $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$
$T_A = 119 - (0.31 + 2.4)(25)$
$T_A = 51^{\circ}C$

Solution 2:

Steps 1 thru 5 are as above.
Step 6: Find $T_A = T_1$ from Figure 10. Read $T_A = 115^{\circ}C$.
Step 7: Compute T_A from $T_A = T_1 - (175 - (T_{J(max)}) - P_R R_{\theta JA}$
$T_A = 115 - (175 - 119) - (0.31)(25)$
$T_A = 51^{\circ}C$

At times, a discrepancy between methods will occur because thermal response is factored into Solution 2.

FIGURE 12 – SINE WAVE INPUT DISSIPATION

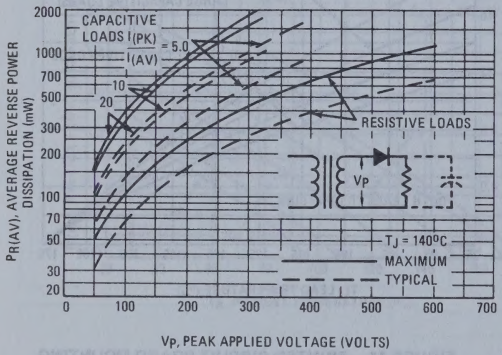


FIGURE 13 – SQUARE WAVE INPUT DISSIPATION

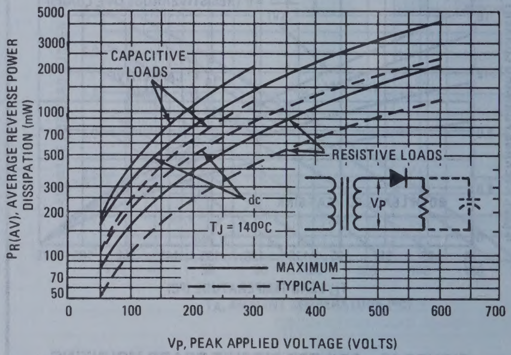


FIGURE 14 – NORMALIZED REVERSE CURRENT

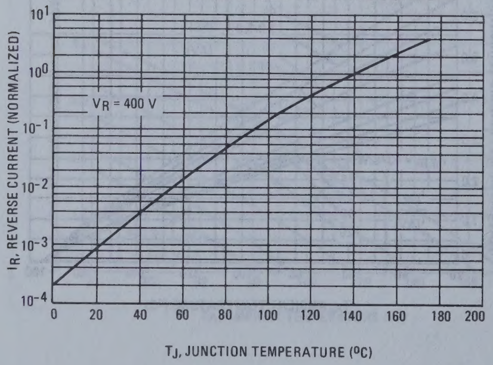
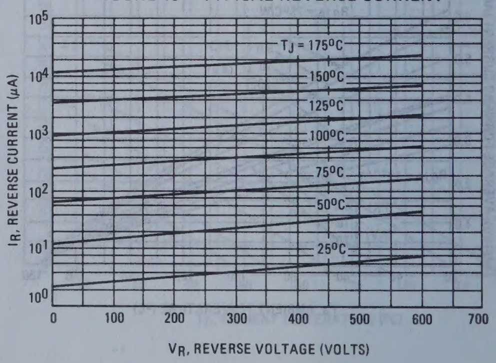


FIGURE 15 – TYPICAL REVERSE CURRENT



STATIC CHARACTERISTICS

FIGURE 16 – FORWARD VOLTAGE

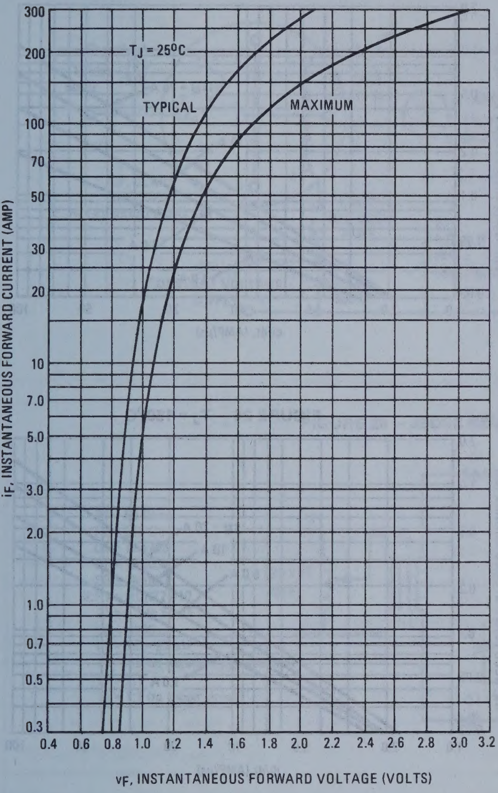


FIGURE 17 – MAXIMUM SURGE CAPABILITY

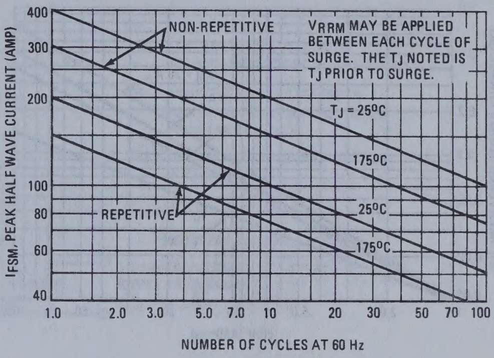
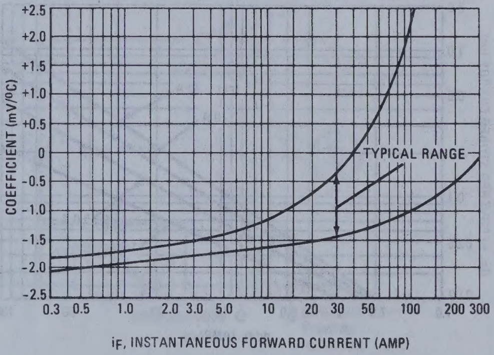


FIGURE 18 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



MAXIMUM FORWARD POWER DISSIPATION

FIGURE 19 – SINE WAVE INPUT

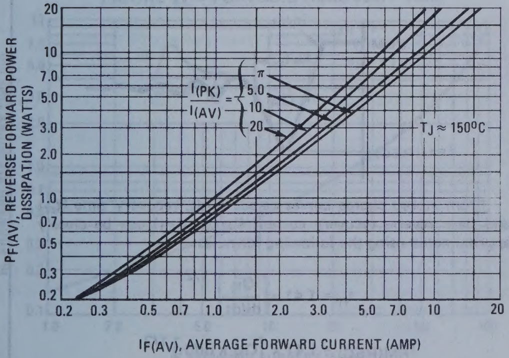
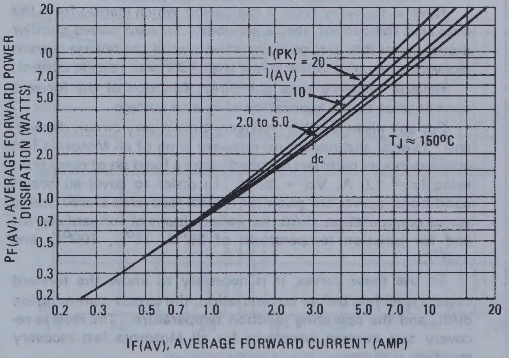


FIGURE 20 – SQUARE WAVE INPUT



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 4)

FIGURE 21 – T_J = 25°C

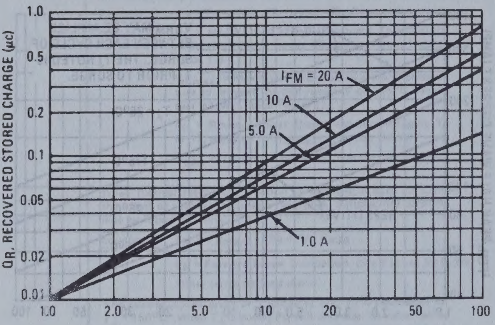


FIGURE 22 – T_J = 75°C

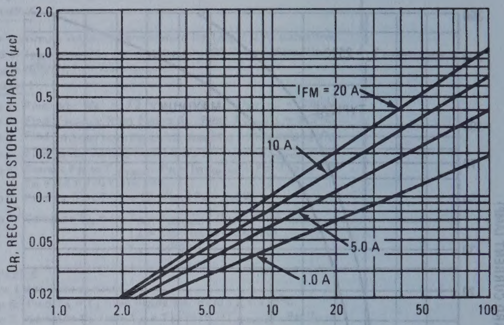


FIGURE 23 – T_J = 100°C

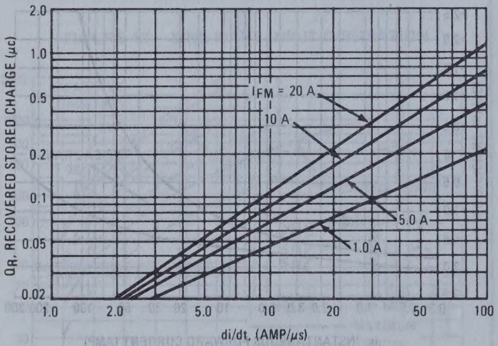
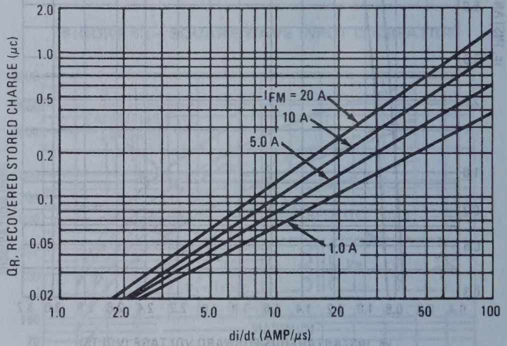


FIGURE 24 – T_J = 150°C



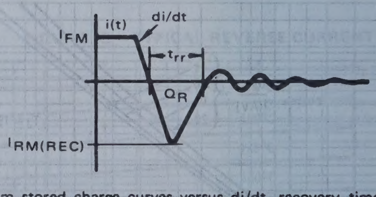
NOTE 4

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



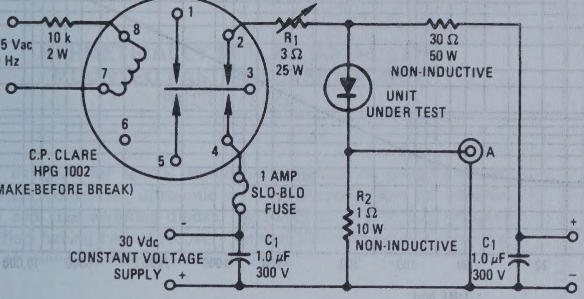
From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

DYNAMIC CHARACTERISTICS

FIGURE 25 – REVERSE RECOVERY CIRCUIT


115 Vac
60 Hz
10 k
2 W
1
2
3
4
5
6
7
8
C.P. CLARE
HPG 1002
(MAKE-BEFORE BREAK)
R_1
3 Ω
25 W
30 Ω
50 W
NON-INDUCTIVE
UNIT
UNDER TEST
A
1 AMP
SLO-BLO
FUSE
R_2
1 Ω
10 W
NON-INDUCTIVE
30 Vdc
CONSTANT VOLTAGE
SUPPLY
-
+
C_1
1.0 μF
300 V
C_1
1.0 μF
300 V
+
–

1.0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = 1½ Ω MAX, DC to 2 kHz

A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1.4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 μH

R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

$T_A = 25 {}^{+10}_{-0}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

FIGURE 26 – JEDEC REVERSE RECOVERY CIRCUIT

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4933
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1:1
T3 = 1:1 (to trigger circuit)

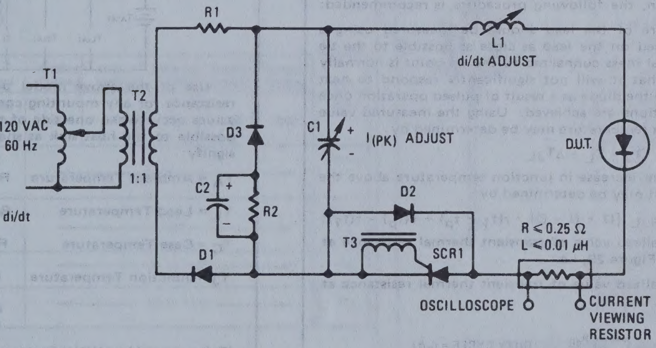

T1
120 VAC
60 Hz
T2
1:1
R1
D3
C1
+
-
$I_{(PK)}$ ADJUST
C2
+
-
R2
D1
L1
di/dt ADJUST
D.U.T.
D2
T3
SCR1
R ≤ 0.25 Ω
L ≤ 0.01 μH
OSCILLOSCOPE
CURRENT
VIEWING
RESISTOR

FIGURE 27 – FORWARD RECOVERY TIME

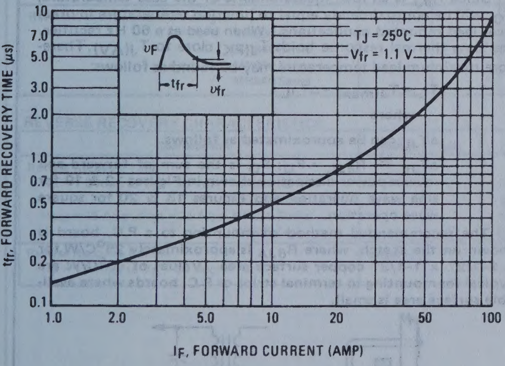
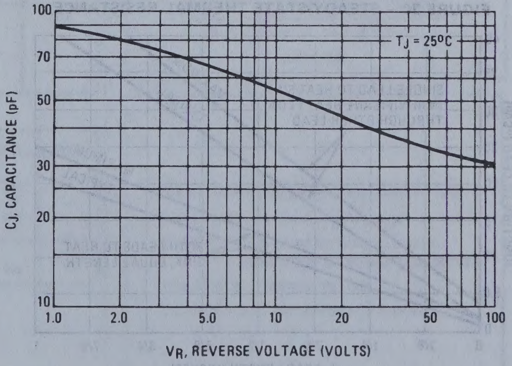
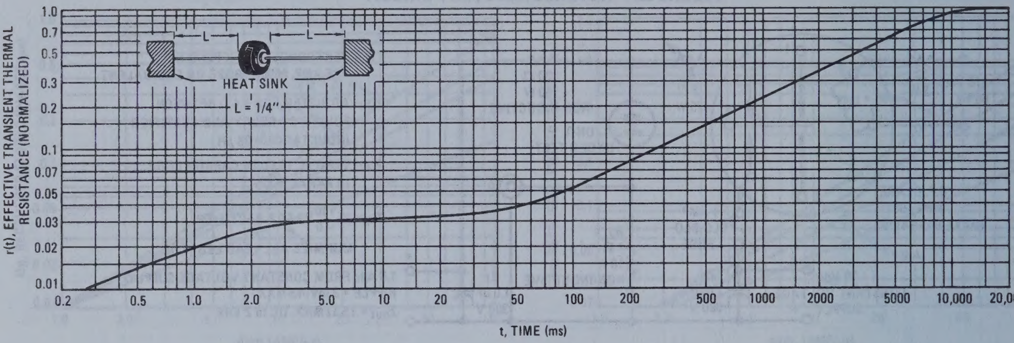


FIGURE 28 – JUNCTION CAPACITANCE



THERMAL CHARACTERISTICS

FIGURE 29 – THERMAL RESPONSE



NOTE 5

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

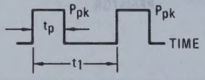
$$T_J = T_L + \Delta T_{JL}$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

$$\Delta T_{JL} = P_{pk} \cdot R_{\theta JL} \left[D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)\right]$$

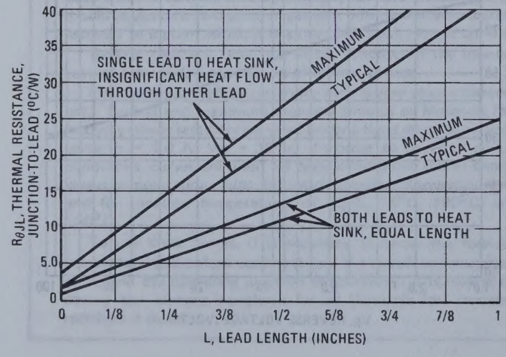
where $r(t)$ = normalized value of transient thermal resistance at time t from Figure 29, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

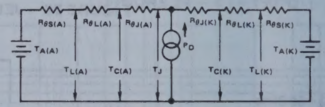


DUTY CYCLE = t_p/t_1
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

FIGURE 30 – STEADY-STATE THERMAL RESISTANCE



NOTE 6



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. Lowest values occur when one side of the rectifier is brought as close as possible to the heat sink as shown below. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts (A) and (K) refer to anode and cathode sides respectively) Values for thermal resistance components are:

$R_{\theta L}$ = 40°C/W/IN. Typically and 44°C/W/IN Maximum.
$R_{\theta J}$ = 2°C/W Typically and 4°C/W Maximum.

Since $R_{\theta J}$ is so low, measurements of the case temperature, T_C, will be approximately equal to junction temperature in practical lead mounted applications. When used as a 60 Hz rectifier, the slow thermal response holds $T_{J(PK)}$ close to $T_{J(AV)}$. Therefore maximum lead temperature may be found as follows:

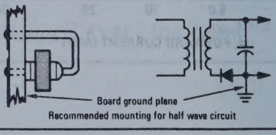
$$T_L = T_{J(max)} - \Delta T_{JL}$$

where

ΔT_{JL} can be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \cdot P_D$; P_D is the sum of forward and reverse power dissipation shown in Figures 12 & 19 for sine wave operation and Figures 13 & 20 for square wave operation.

The recommended method of mounting to a P.C. board is shown on the sketch, where $R_{\theta JA}$ is approximately 25°C/W for a 1-1/2″ x 1-1/2″ copper surface area. Values of 40°C/W are typical for mounting to terminal strips or P.C. boards where available surface area is small.



Recommended mounting for half wave circuit

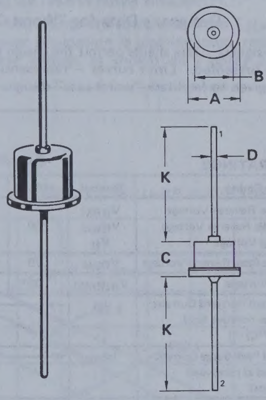
MR830, MR831, MR832
MR834, MR836
MR840, MR841, MR842
MR844, MR846

HERMETICALLY SEALED, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
3 AMPERES



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60

MAXIMUM RATINGS

Rating	Symbol	MR830 MR840	MR831 MR841	MR832 MR842	MR834 MR844	MR836 MR846	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^\circ C$)	I_O	← 3.0 →					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 100 →					Amps
Operating Junction Temperature Range	T_J	← -65 to +150 →					°C
Storage Temperature Range	T_{stg}	← -65 to +175 →					°C

ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Forward Voltage ($I_F = 3.0$ Adc, $T_A = 25^\circ C$)	MR830 Series	V_F	–	1.1	Volts
	MR840 Series		–	1.2	
Reverse Current (rated DC Voltage) $T_A = 25^\circ C$	MR830 Series	I_R	–	0.05	mA
	MR840 Series		–	0.075	
$T_A = 100^\circ C$	MR830 Series		–	1.5	
	MR840 Series		–	2.5	

REVERSE RECOVERY CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc)	MR830 Series	t_{rr}	–	100	200	ns
	MR840 Series		–	0.5	1.0	μs
($I_{FM} = 15$ Amp, di/dt = 25 A/μs)	MR830 Series		–	150	300	ns
	MR840 Series		–	0.75	1.5	μs
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc)		$I_{RM(REC)}$	–	–	2.0	Amp

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and leads readily solderable

POLARITY: Cathode to Case

WEIGHT: 2.4 Grams (Approximately)

MR850,MR851,MR852, MR854,MR856

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR850	MR851	MR852	MR854	MR856	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase resistive load, $T_A = 90^oC$) (1)	I_O	← 3.0 →					Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 100 → (one cycle)					Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	← -65 to +175 →					^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mouting, See Note 6, Page 8)	$R_{\theta JA}$	28	$^oC/W$

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 9.4$ Amp, $T_J = 175^oC$)	v_F	—	0.9	1.1	Volts
Forward Voltage ($I_F = 3.0$ Amp, $T_J = 25^oC$)	V_F	—	1.04	1.25	Volts
Reverse Current (rated dc voltage) $T_J = 25^oC$	I_R	—	2.0	10	μA
$T_J = 100^oC$ MR850		—	—	150	
MR851		—	60	150	
MR852		—	—	200	
MR854		—	—	250	
MR856		—	100	300	

REVERSE RECOVERY CHARACTERISTICS

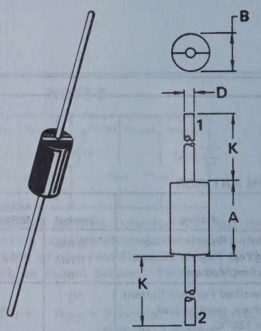
Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 25) ($I_F = 15$ Amp, di/dt = 10 A/μs, Figure 26)	t_{rr}	 — —	 100 150	 200 300	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 25)	$I_{RM(REC)}$	—	—	2.0	Amp

(1) Must be derated for reverse power dissipation. See Note 2, Page 3.

(2) Derate as shown in Figure 1

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
3 AMPERE



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

CASE 267-01

MECHANICAL CHARACTERISTICS

Case: Void Free, Transfer Molded

Finish: External Leads are Plated, Leads are readily Solderable

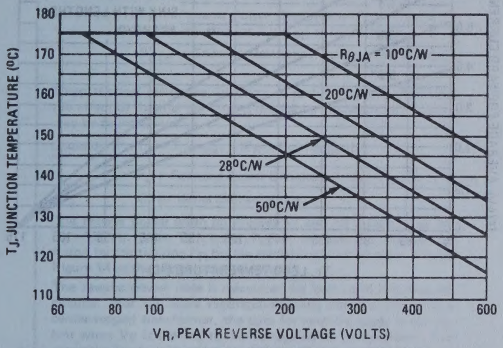
Polarity: Cathode Indicated by Polarity Band

Weight: 1.1 Grams (Approximately)

Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8" from case for 10 s at 5.0 lb. tension

MAXIMUM CURRENT AND TEMPERATURE RATINGS

FIGURE 1 – MAXIMUM ALLOWABLE JUNCTION TEMPERATURE



NOTE 1
MAXIMUM JUNCTION TEMPERATURE DERATING

When operating this rectifier at junction temperatures over 120°C, reverse power dissipation and the possibility of thermal runaway must be considered. The data of Figure 1 is based upon worst case reverse power and should be used to derate $T_{J(max)}$ from its maximum value of 175°C. See Note 2 for additional information on derating for reverse power dissipation.

When current ratings are computed from $T_{J(max)}$ and reverse power dissipation is also included, ratings vary with reverse voltage as shown on Figures 2 thru 5.

RESISTIVE LOAD RATINGS

Printed Circuit Board Mounting — See Note 6, Page 8

FIGURE 2 – SINE WAVE INPUT

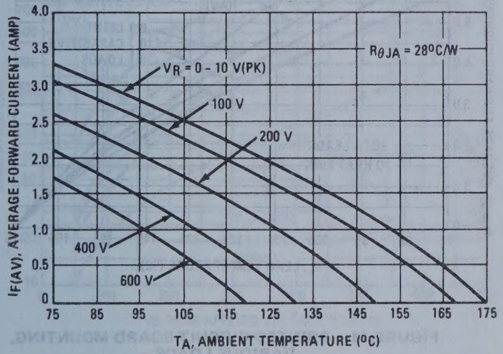


FIGURE 3 – SQUARE WAVE INPUT

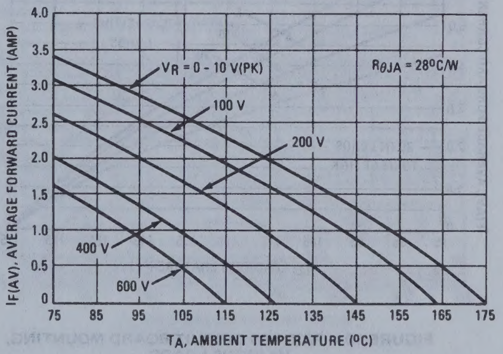


FIGURE 4 – SINE WAVE INPUT

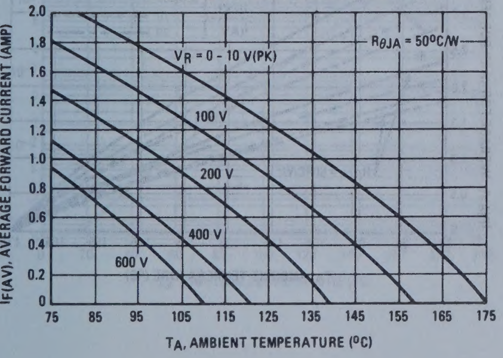
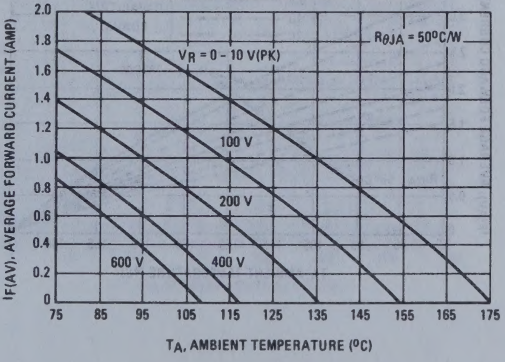


FIGURE 5 – SQUARE WAVE INPUT



MAXIMUM CURRENT RATINGS

Current derating data is based upon the thermal response data of Figure 29 and the forward power dissipation data of Figures 19 and 20. Since reverse power dissipation is not considered in Figures 6 thru 11, additional derating for reverse voltage and for junction to ambient thermal resistance must be applied. See Note 2.

SINE WAVE INPUTS

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

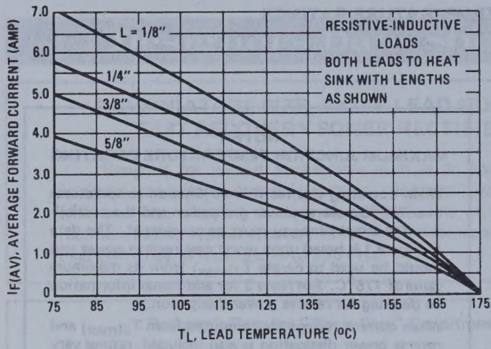


FIGURE 8 – 1/8″ LEAD LENGTH, VARIOUS LOADS

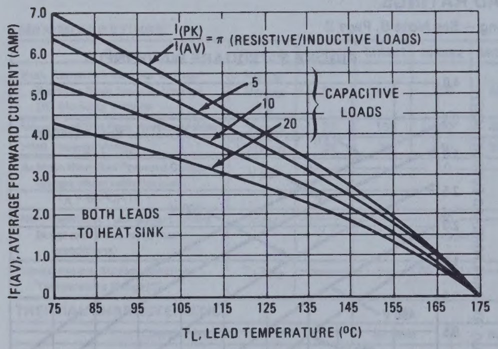
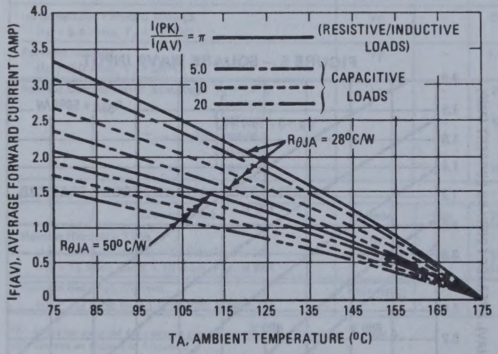


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUTS

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

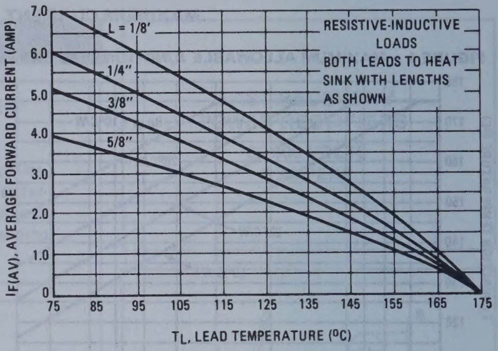


FIGURE 9 – 1/8″ LEAD LENGTH, VARIOUS LOADS

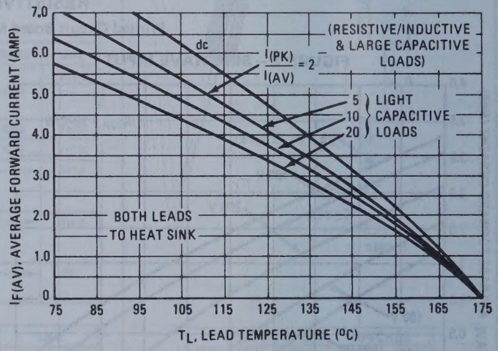
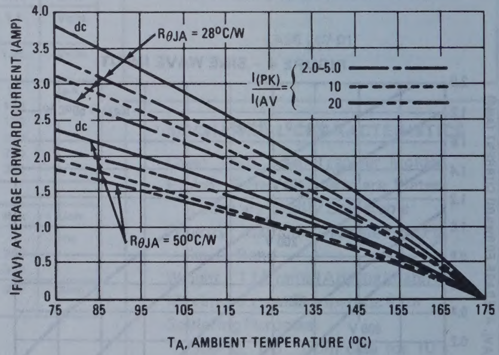


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



REVERSE POWER DISSIPATION AND CURRENT

NOTE 2
DERATING FOR REVERSE POWER DISSIPATION

In this rectifier, power loss due to reverse current is generally not negligible. For reliable circuit design, the maximum junction temperature must be limited to either 175°C or the temperature which results in thermal runaway. Proper derating may be accomplished by use of equation 1 or equation 2.

Equation 1 $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$

Where: T_1 = Maximum Allowable Ambient Temperature neglecting reverse power dissipation (from Figures 10 or 11)

$T_{J(max)}$ = Maximum Allowable Junction Temperature to prevent thermal runaway or 175°C, which ever is lower. (See Figure 1).

P_R = Reverse Power Dissipation (From Figure 12 or 13, adjusted for $T_{J(max)}$ as shown below)

$R_{\theta JA}$ = Thermal Resistance, Junction to Ambient.

When thermal resistance, junction to ambient, is over 20°C/W, the effect of thermal response is negligible. Satisfactory derating may be found by using:

Equation 2 $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$

P_F = Forward Power Dissipation (See Figures 19 & 20)

Other terms defined above.

The reverse power given on Figures 12 and 13 is calculated for $T_J = 150°C$. When T_J is lower, P_R will decrease; its value can be found by multiplying P_R by the normalized reverse current from Figure 14 at the temperature of interest.

The reverse power data is calculated for half wave rectification circuits. For full wave rectification using either a bridge or a center-tapped transformer, the data for resistive loads is equivalent when V_P is the line to line voltage across the rectifiers. For capacitive loads, it is recommended that the dc case on Figure 13 be used, regardless of input waveform, for bridge circuits. For capacitively loaded full wave center-tapped circuits, the 20:1 data of Figure 12 should be used for sine wave inputs and the capacitive load data of Figure 13 should be used for square wave inputs regardless of $I_{(pk)}/I_{(av)}$. For these two cases, V_P is the voltage across one leg of the transformer.

Example 1 Find maximum ambient temperature for $I_{AV} = 2$ A, capacitive load of $I_{PK}/I_{AV} = 20$, Input Voltage = 60 V (rms), sine wave, $R_{\theta JA} = 28°C/W$, half wave circuit.

Solution 1 (using Equation 1)

Step 1: Find V_P; $V_P = \sqrt{2}\, V_{in} = 85$ V, $V_{R(pk)} = 170$

Step 2: Find $T_{J(max)}$ from Figure 1. Read $T_{J(max)} = 157°C$

Step 3: Find $P_{R(max)}$ from Figure 12. Read $P_R = 360$ mW @ 150°C

Step 4: Find I_R normalized from Figure 14. Read $I_{R(norm)} = 1.5$

Step 5: Correct P_R to $T_{J(max)}$. $P_R = I_{R(norm)} \times P_R$ (Figure 12) $P_R = 1.5 \times 360 = 540$ mW

Step 6: Find $T_A = T_1$ from Figure 10. Read $T_1 = 94°C$

Step 7: Compute T_A from $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$

$$T_A = 94 - (175 - 157) - (0.54)(28)$$
$$T_A = 61°C$$

Solution 2 (using Equation 2)

Steps 1 thru 5 are as Solution 1

Step 6: Find P_F from Figure 19. Read $P_F = 3.0$ W

Step 7: Compute T_A from $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$

$$T_A = 157 - (0.54 + 3) 28$$
$$T_A = 58°C$$

The discrepancy occurs because thermal response is factored into solution 1, and advantage is taken of the cooling time after the power pulse and before reverse voltage achieves its maximum. 61°C is a satisfactory ambient temperature.

FIGURE 12 — REVERSE POWER DISSIPATION, SINE WAVE

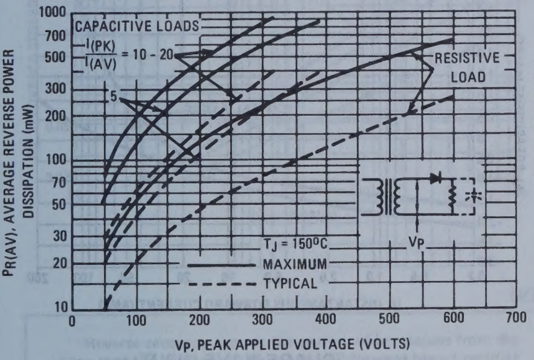


FIGURE 13 — REVERSE POWER DISSIPATION, SQUARE WAVE

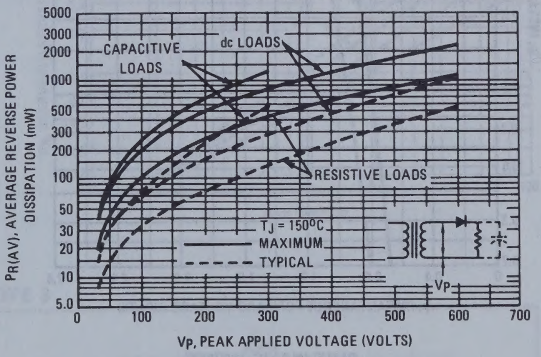


FIGURE 14 — NORMALIZED REVERSE CURRENT

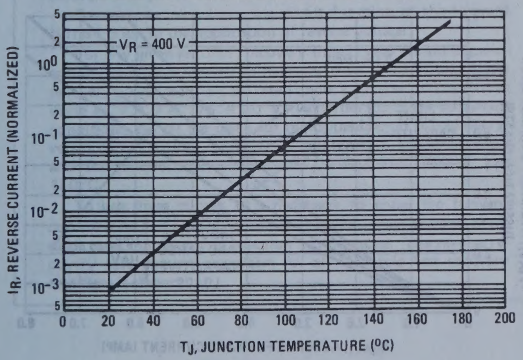
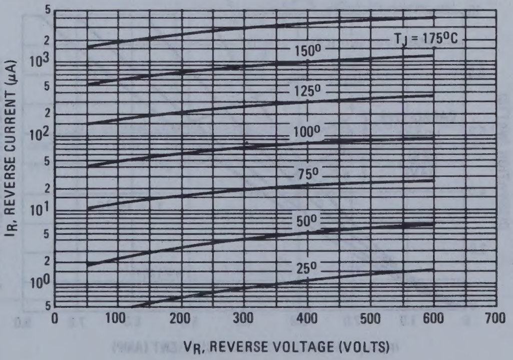


FIGURE 15 — TYPICAL REVERSE CURRENT



STATIC CHARACTERISTICS

FIGURE 16 – FORWARD VOLTAGE

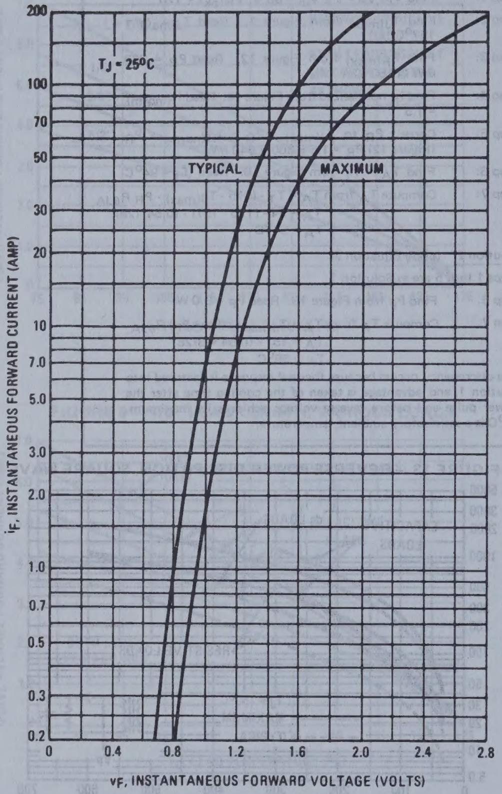


FIGURE 17 – MAXIMUM SURGE CAPABILITY

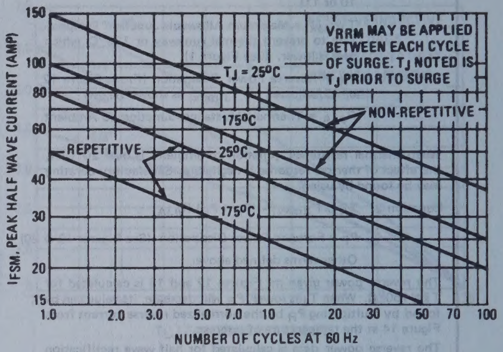
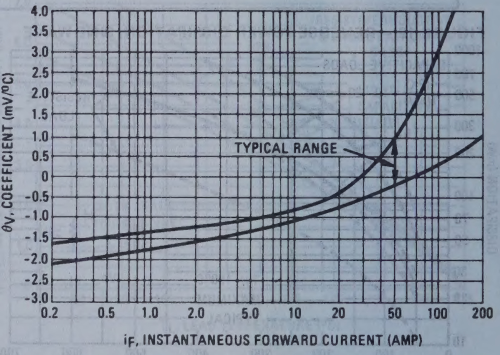
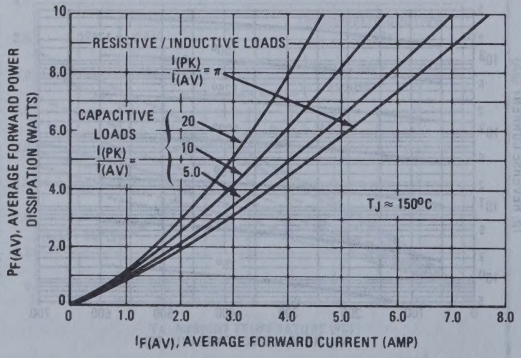


FIGURE 18 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



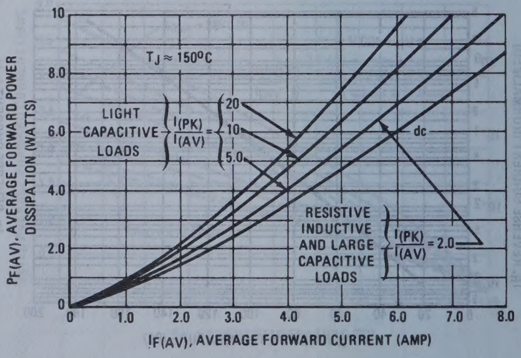
SINE WAVE INPUT

FIGURE 19 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 20 – FORWARD POWER DISSIPATION



TYPICAL RECOVERED STORED CHARAGE DATA

(See Note 3)

FIGURE 21 – $T_J = 25^oC$

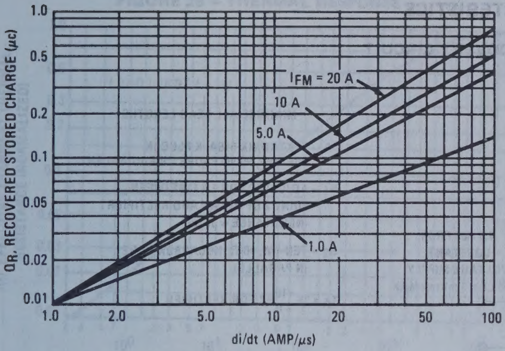


FIGURE 22 – $T_J = 75^oC$

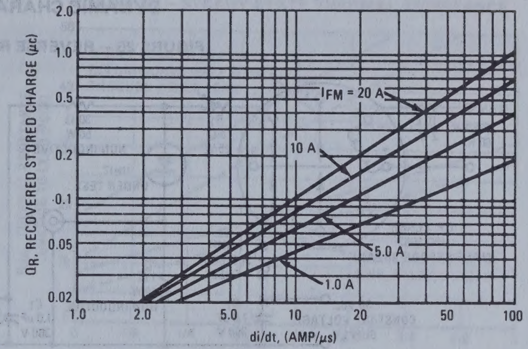


FIGURE 23 – $T_J = 100^oC$

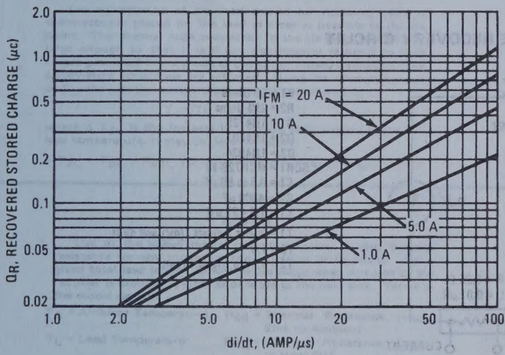
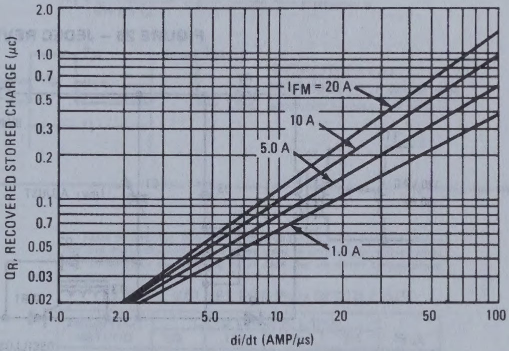


FIGURE 24 – $T_J = 150^oC$



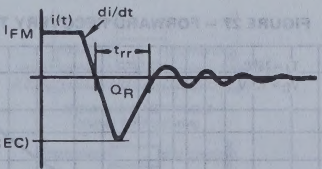
NOTE 3

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



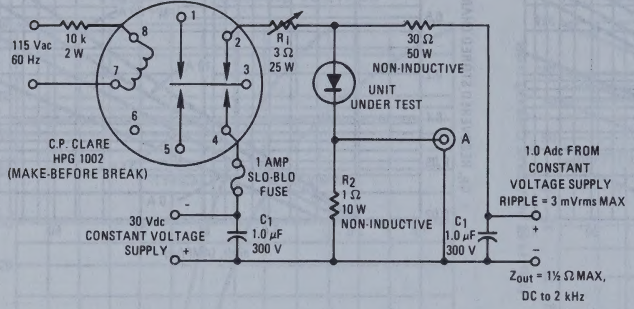
From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

DYNAMIC CHARACTERISTICS

FIGURE 25 – REVERSE RECOVERY CIRCUIT


115 Vac
60 Hz
10 k
2 W
8
7
6
5
1
2
3
4
C.P. CLARE
HPG 1002
(MAKE-BEFORE BREAK)
R1
3 Ω
25 W
30 Ω
50 W
NON-INDUCTIVE
UNIT
UNDER TEST
A
1 AMP
SLO-BLO
FUSE
R2
1 Ω
10 W
NON-INDUCTIVE
30 Vdc
CONSTANT VOLTAGE
SUPPLY
C1
1.0 μF
300 V
C1
1.0 μF
300 V
1.0 Adc FROM
CONSTANT
VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = 1½ Ω MAX,
DC to 2 kHz

MINIMIZE ALL LEAD LENGTHS

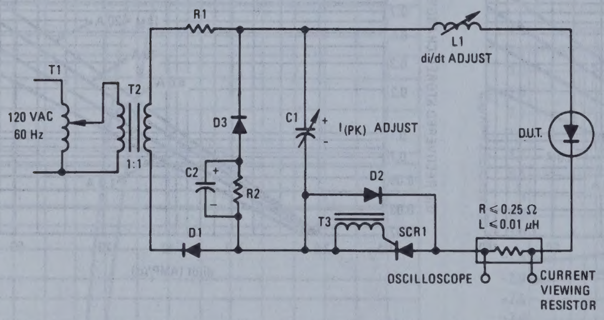
A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1.4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 μH

R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

$T_A = 25 {}^{+10}_{-0}$ °C FOR RECTIFIER

FIGURE 26 – JEDEC REVERSE RECOVERY CIRCUIT


T1
T2
120 VAC
60 Hz
1:1
R1
D3
C2
R2
D1
C1
$I_{(PK)}$ ADJUST
D2
T3
SCR1
L1
di/dt ADJUST
D.U.T.
R ≤ 0.25 Ω
L ≤ 0.01 μH
OSCILLOSCOPE
CURRENT
VIEWING
RESISTOR

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4934
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 – 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1:1
T3 = 1:1 (to trigger circuit)

FIGURE 27 – FORWARD RECOVERY TIME

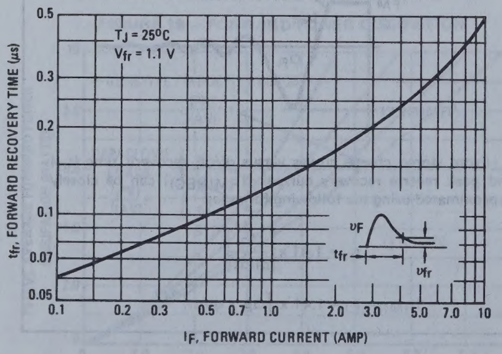


FIGURE 28 – JUNCTION CAPACITANCE

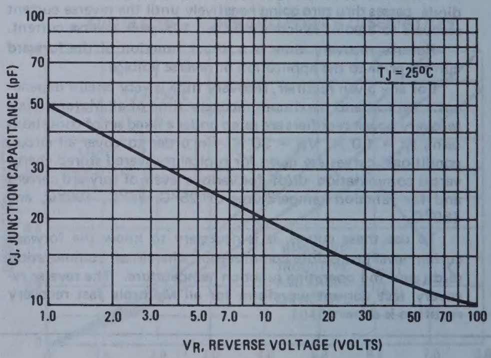


FIGURE 29 – THERMAL RESPONSE

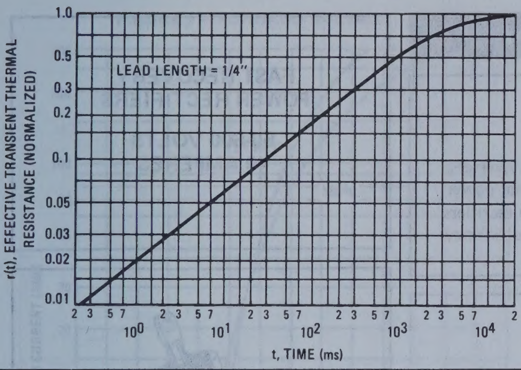
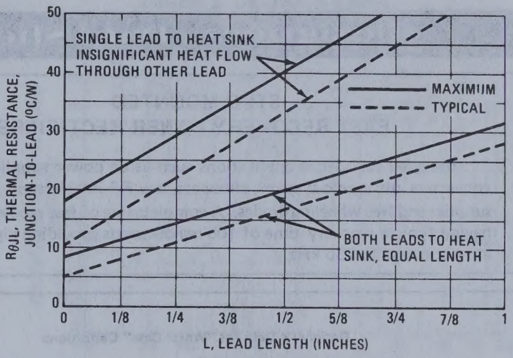


FIGURE 30 – STEADY-STATE THERMAL RESISTANCE



NOTE 4

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

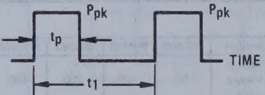
$$T_J = T_L + \Delta T_{JL}$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

$$\Delta T_{JL} = P_{pk} \cdot R_{\theta JL} \left[D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)\right]$$

where $r(t)$ = normalized value of transient thermal resistance at time t from Figure 29, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.



DUTY CYCLE = t_p/t_1
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

NOTE 5

Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Total Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts (A) and (K) refer to anode and cathode sides respectively.) Values for thermal resistance components are:

$R_{\theta L}$ = 46°C/W/IN. Typically and 48°C/W/IN Maximum.
$R_{\theta J}$ = 10°C/W Typically and 16°C/W Maximum.

The maximum lead temperature may be found as follows:

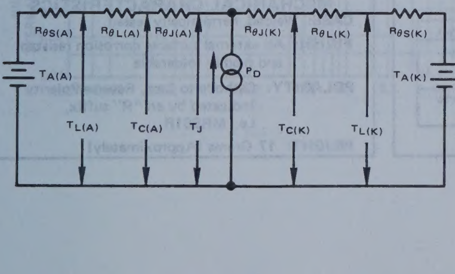
$$T_L = T_{J(max)} - \Delta T_{JL}$$

where

ΔT_{JL} can be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \cdot P_D$; P_D is the sum of forward and reverse power dissipation shown in Figures 2 and 4 for sine wave operation and Figures 3 and 5 for square wave operation.

THERMAL CIRCUIT MODEL
(For Heat Conduction Through the Leads)



NOTE 6

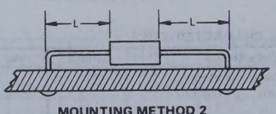
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

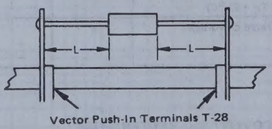
MOUNTING METHOD	LEAD LENGTH, L (IN)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.

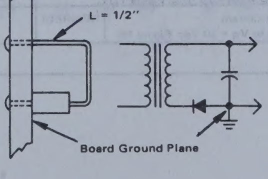


MOUNTING METHOD 2
Vector Pin Mounting



MOUNTING METHOD 3

P.C. Board with
1-1/2" x 1-1/2" Copper Surface



MR860, MR861, MR862, MR864, MR866

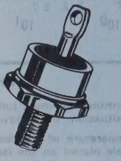
Designers Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
40 AMPERES



Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR860	MR861	MR862	MR864	MR866	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^\circ C$)	I_O	← 40 →					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 350 →					Amps
Operating Junction Temperature Range	T_J	← -65 to +160 →					°C
Storage Temperature Range	T_{stg}	← -65 to +175 →					°C

THERMAL CHARACTERISTICS

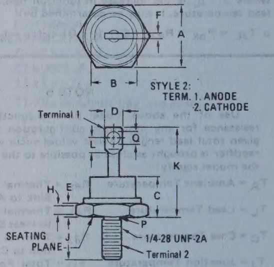
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.85	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 125$ Amp, $T_J = 150^\circ C$)	v_F	–	1.3	1.6	Volts
Forward Voltage ($I_F = 40$ Amp, $T_C = 25^\circ C$)	V_F	–	1.0	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25^\circ C$ $T_C = 100^\circ C$	I_R	– –	25 1.0	50 2.0	µA mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16) ($I_{FM} = 36$ Amp, $di/dt = 25$ A/µs, Figure 17)	t_{rr}	 – –	 100 200	 200 400	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	$I_{RM(REC)}$	–	2.0	3.0	Amp



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.94	17.45	0.667	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
H	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.152	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175

NOTES:
1. Dimension "P" is diameter.
2. All JEDEC dimensions and notes apply.

CASE 257-01
DO-203AB

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case, Reverse Polarity Indicated by an "R" suffix, i.e., MR861R

WEIGHT: 17 Grams (Approximately)

FIGURE 1 – FORWARD VOLTAGE

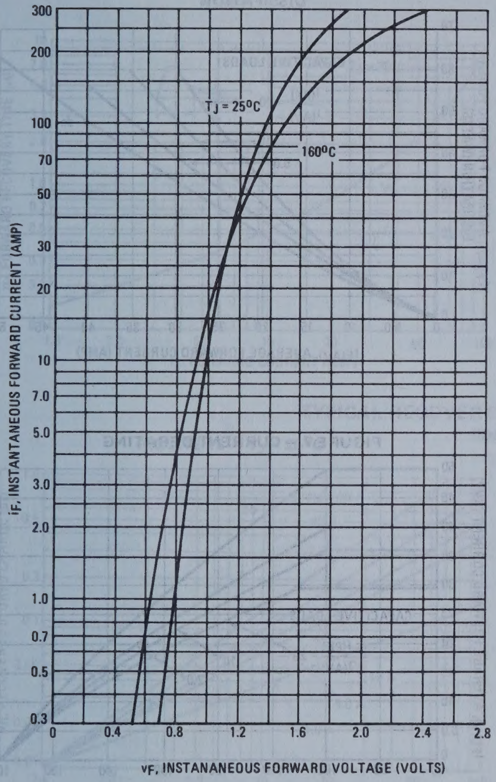
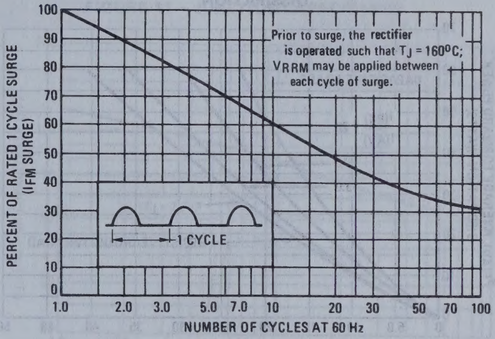
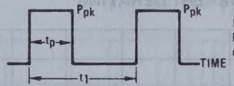


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \triangle T_{JC}$$

where $\triangle T_{JC}$ is the increase in junction temperature above the case temperature. It may be determined by:

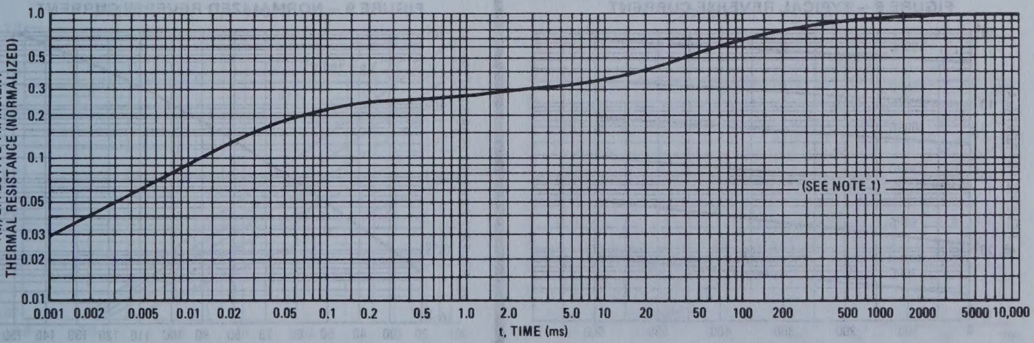
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION

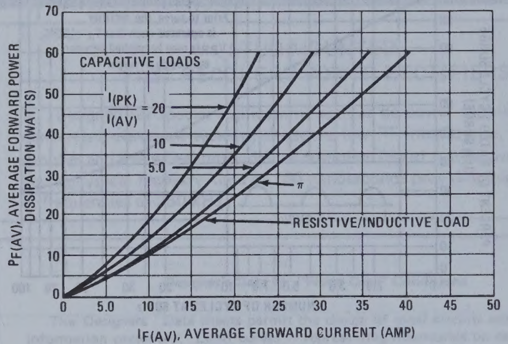


FIGURE 6 – CURRENT DERATING

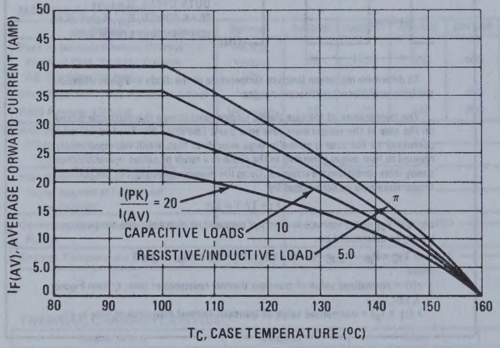
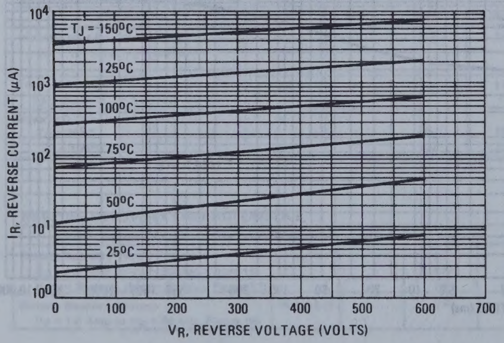


FIGURE 8 – TYPICAL REVERSE CURRENT



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

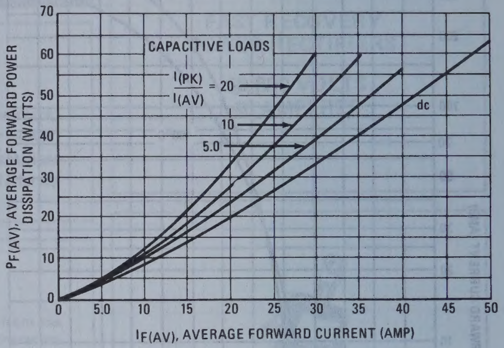


FIGURE 7 – CURRENT DERATING

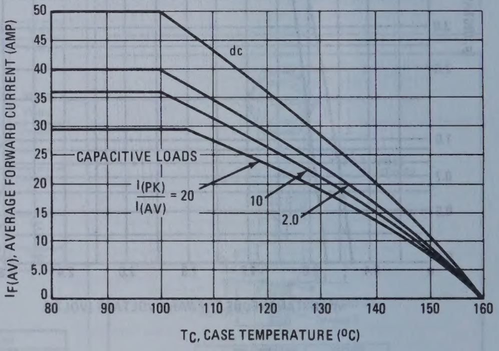


FIGURE 9 – NORMALIZED REVERSE CURRENT

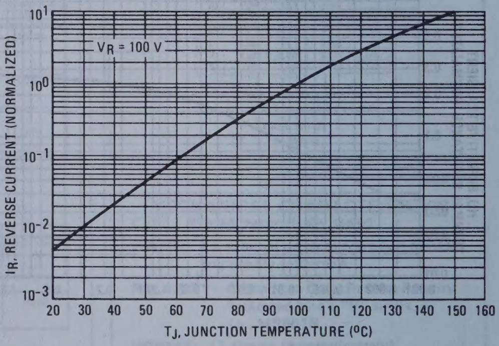


FIGURE 10 – FORWARD RECOVERY TIME

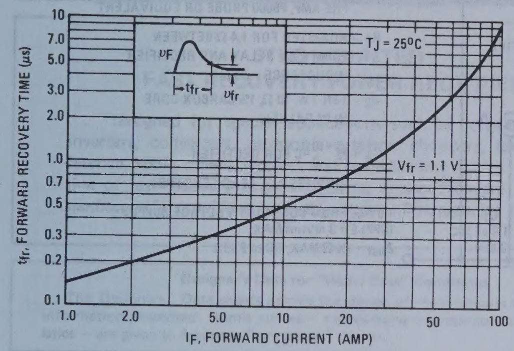
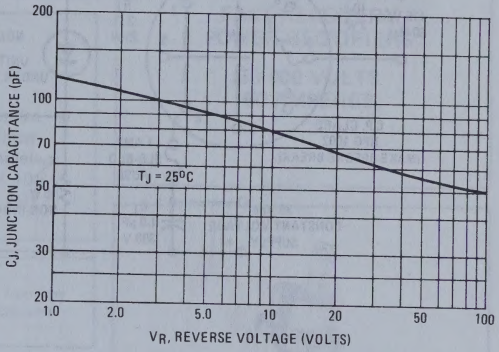


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25°C$

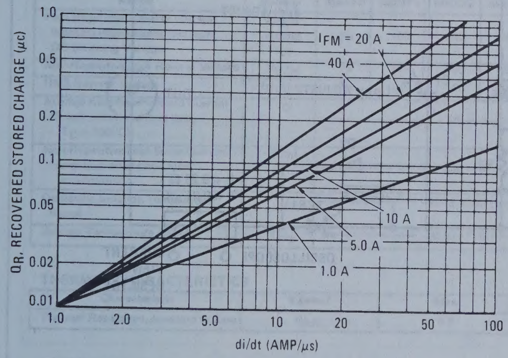


FIGURE 13 – $T_J = 75°C$

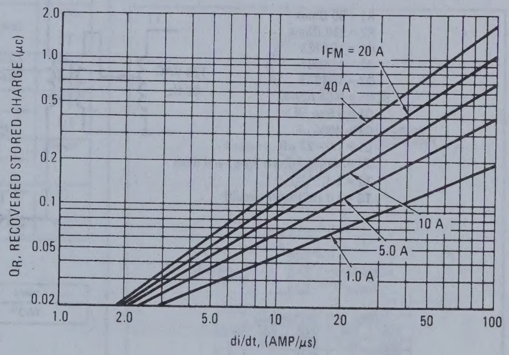


FIGURE 14 – $T_J = 100°C$

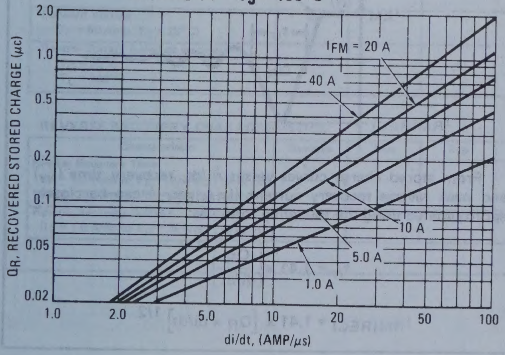


FIGURE 15 – $T_J = 150°C$

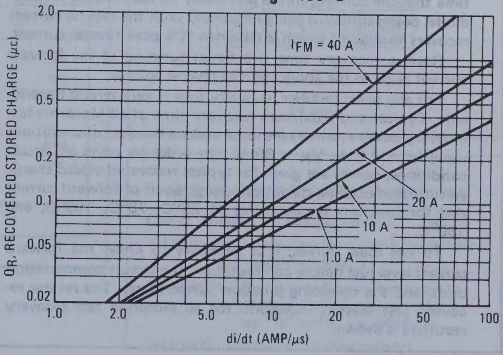
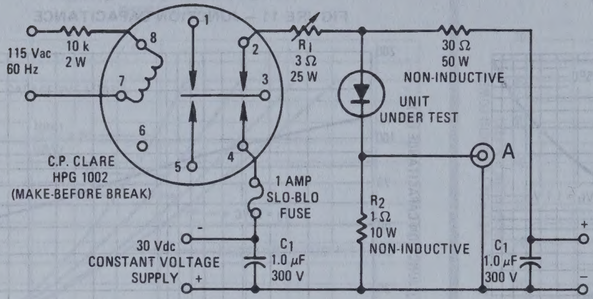


FIGURE 16 – REVERSE RECOVERY CIRCUIT


115 Vac
60 Hz
10 k
2 W
1
2
3
4
5
6
7
8
C.P. CLARE
HPG 1002
(MAKE-BEFORE BREAK)
R1
3 Ω
25 W
30 Ω
50 W
NON-INDUCTIVE
UNIT
UNDER TEST
A
1 AMP
SLO-BLO
FUSE
R2
1 Ω
10 W
NON-INDUCTIVE
30 Vdc
CONSTANT VOLTAGE
SUPPLY
C1
1.0 μF
300 V
C1
1.0 μF
300 V
+
–

A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1.4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 μH

R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

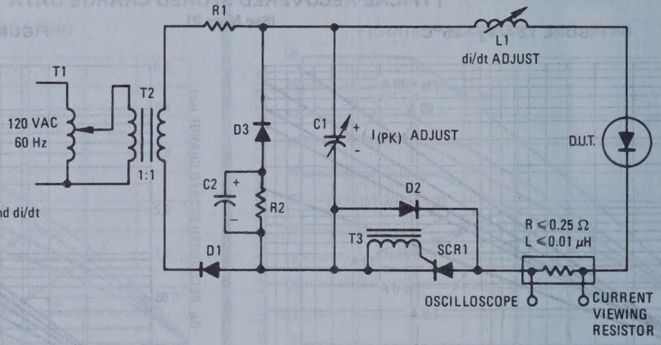
$T_A = 25\ ^{+10}_{-0}\ ^\circ C$ FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

+ 1.0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
– Z_{out} = 1½ Ω MAX, DC to 2 kHz

FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4933
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1:1
T3 = 1:1 (to trigger circuit)


R1
L1
di/dt ADJUST
T1
T2
120 VAC
60 Hz
1:1
D3
C1
+
–
I(PK) ADJUST
D.U.T.
C2
+
–
R2
D2
R ≤ 0.25 Ω
L ≤ 0.01 μH
T3
SCR1
D1
OSCILLOSCOPE
CURRENT
VIEWING
RESISTOR

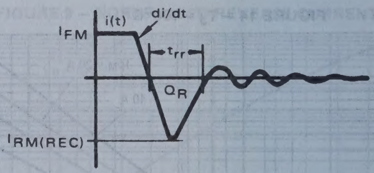
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.


di/dt
i(t)
I_FM
t_rr
Q_R
I_RM(REC)

From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

MR870, MR871, MR872, MR874, MR876

Designers Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR870	MR871	MR872	MR874	MR876	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^oC$)	I_O	← 50 →					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 400 →					Amps
Operating Junction Temperature Range	T_J	← -65 to +160 →					^oC
Storage Temperature Range	T_{stg}	← -65 to +175 →					^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	$^oC/W$

ELECTRICAL CHARACTERISTICS

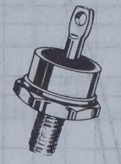
Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 157$ Amp, $T_J = 160^oC$)	v_F	–	1.3	1.6	Volts
Forward Voltage ($I_F = 50$ Amp, $T_C = 25^oC$)	V_F	–	1.1	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25^oC$ $T_C = 100^oC$	I_R	– –	25 1.0	50 2.0	μA mA

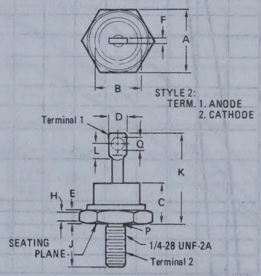
REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16) ($I_{FM} = 36$ Amp, di/dt = 25 A/μs, Figure 17)	t_{rr}	 – –	 120 240	 200 400	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	$I_{RM(REC)}$	–	2.0	3.0	Amp

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
50 AMPERES





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.94	17.45	0.667	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
H	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.152	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175

NOTES:
1. Dimension "P" is diameter.
2. All JEDEC dimensions and notes apply.

CASE 257-01
DO-203AB

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case is standard. Reverse Polarity indicated by an "R" suffix, i.e., MR871R.

WEIGHT: 17 Grams (Approximately)

FIGURE 1 – FORWARD VOLTAGE

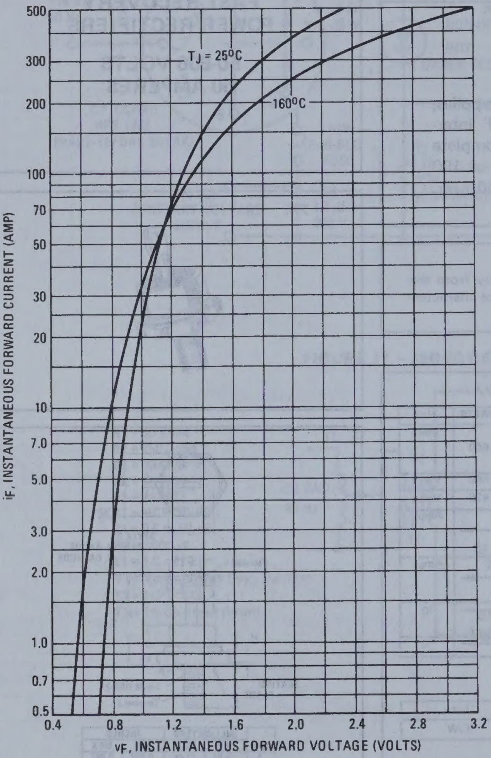
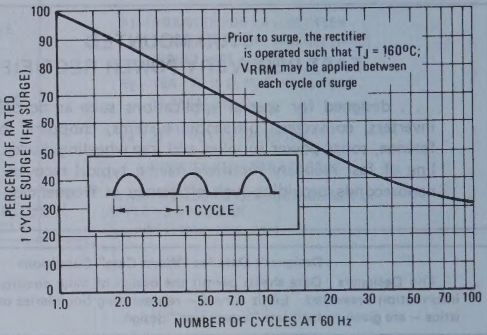
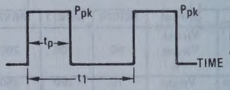


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

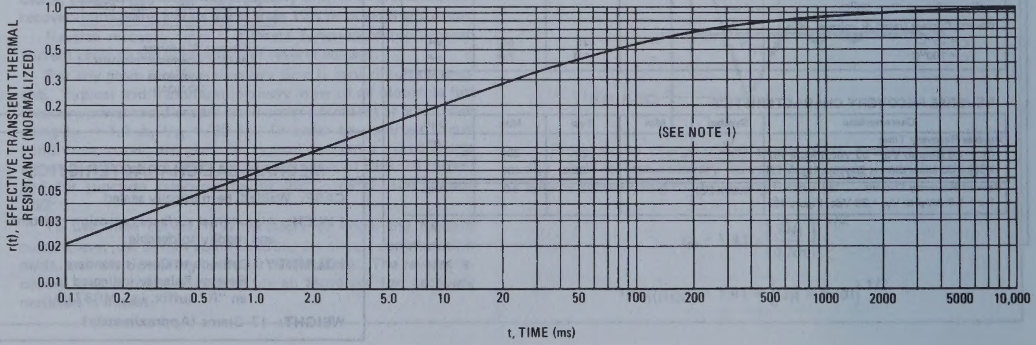
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 — FORWARD POWER DISSIPATION

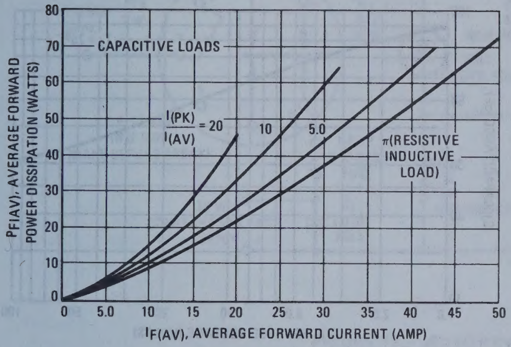


FIGURE 6 — CURRENT DERATING

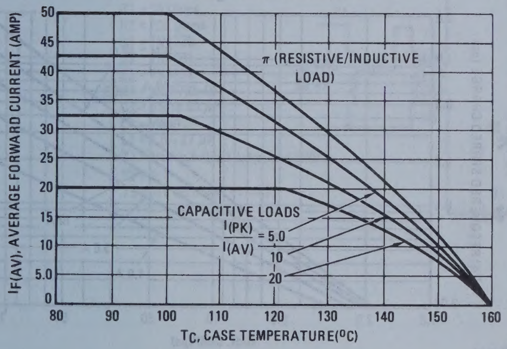
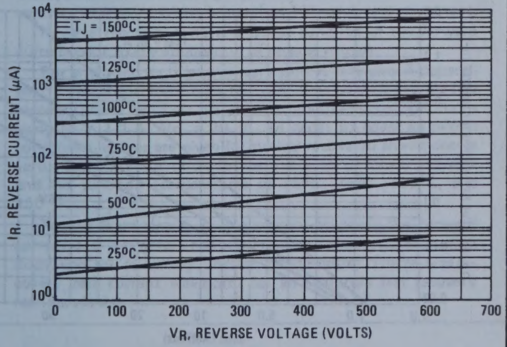


FIGURE 8 — TYPICAL REVERSE CURRENT



SQUARE WAVE INPUT

FIGURE 5 — FORWARD POWER DISSIPATION

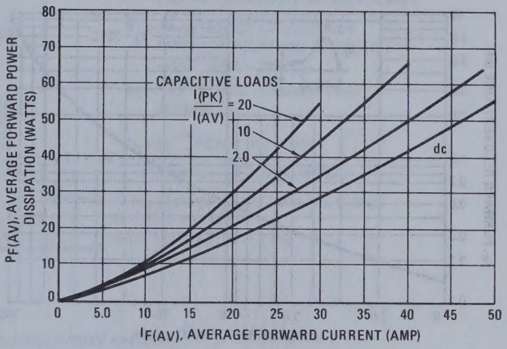


FIGURE 7 — CURRENT DERATING

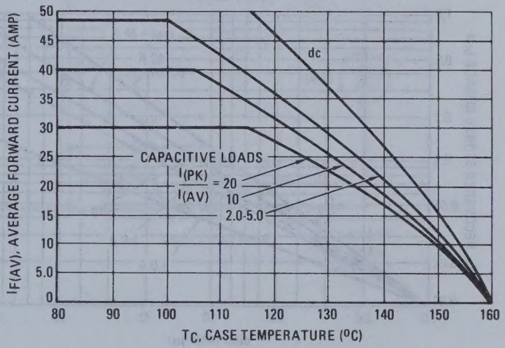
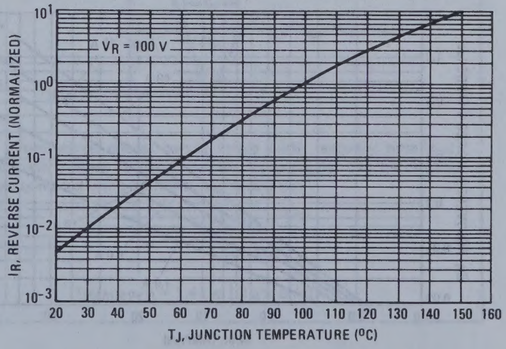


FIGURE 9 — NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 — FORWARD RECOVERY TIME

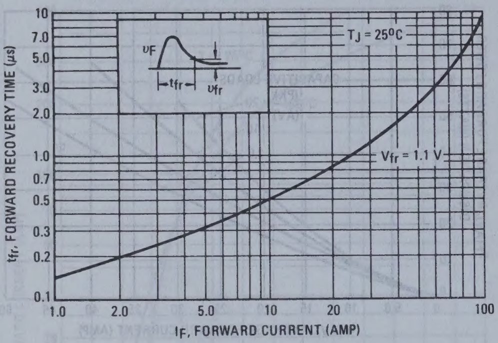
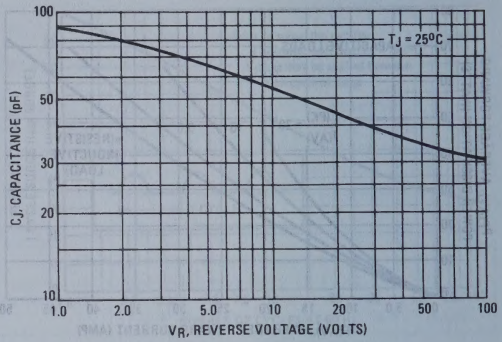


FIGURE 11 — JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 — T_J = 25°C

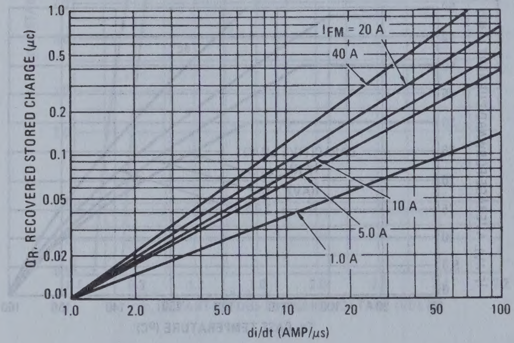


FIGURE 13 — T_J = 75°C

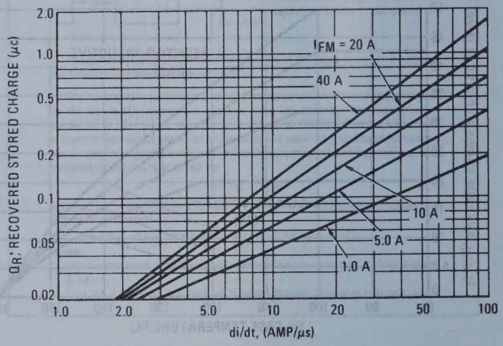


FIGURE 14 — T_J = 100°C

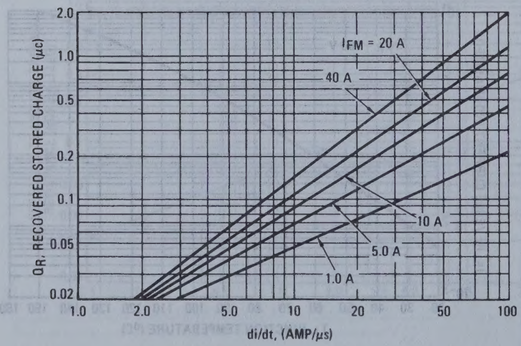


FIGURE 15 — T_J = 150°C

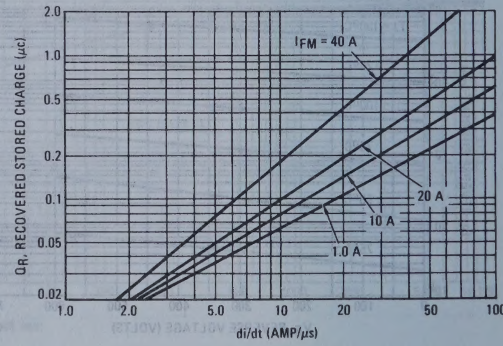
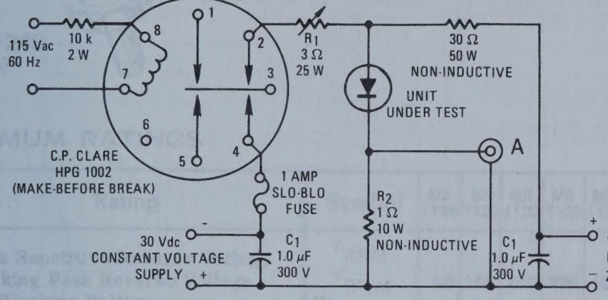


FIGURE 16 – REVERSE RECOVERY CIRCUIT


115 Vac
60 Hz
10 k
2 W
1
2
3
4
5
6
7
8
C.P. CLARE
HPG 1002
(MAKE-BEFORE BREAK)
R1
3 Ω
25 W
30 Ω
50 W
NON-INDUCTIVE
UNIT
UNDER TEST
A
1 AMP
SLO-BLO
FUSE
R2
1 Ω
10 W
NON-INDUCTIVE
C1
1.0 μF
300 V
C1
1.0 μF
300 V
30 Vdc
CONSTANT VOLTAGE
SUPPLY
+
-

A – TEKTRONIX 545A, K PLUG IN
PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1.4 Ω BETWEEN
POINT 2 OF RELAY AND RECTIFIER
INDUCTANCE ≈ 38 μH

R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE
IN PARALLEL

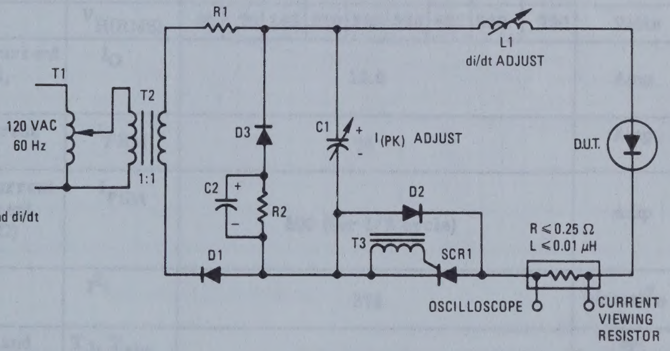
$T_A = 25^{+10}_{-0}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1.0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = 1½ Ω MAX, DC to 2 kHz

FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4933
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1:1
T3 = 1:1 (to trigger circuit)


R1
T1
T2
120 VAC
60 Hz
1:1
L1
di/dt ADJUST
D3
C1
+
-
I(PK) ADJUST
D.U.T.
C2
+
-
R2
D2
T3
SCR1
R ≤ 0.25 Ω
L ≤ 0.01 μH
D1
OSCILLOSCOPE
CURRENT
VIEWING
RESISTOR

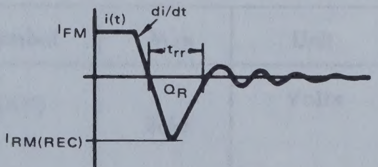
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

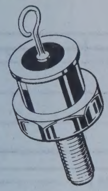
$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

MR1030 thru MR1036, MR1038, MR1040

For Specifications, See 1N4719 Data, Volume I.

MR1120 thru MR1126 (SILICON)
MR1128
MR1130



CASE 245
(DO-4)

Medium-current silicon rectifiers feature high surge current capacity, and low forward voltage drop.

MAXIMUM RATINGS

Rating	Symbol	MR 1120	MR 1121	MR 1122	MR 1123	MR 1124	MR 1125	MR 1126	MR 1128	MR 1130	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RSM}	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, $T_C = 150^oC$)	I_O	12.0									Amp
Peak Repetitive Forward Current ($T_C = 150^oC$)	I_{FRM}	75									Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_C = 150^oC$)	I_{FSM}	300 (for 1/2 cycle)									Amp
I^2t Rating (non-repetitive, 1 msec $< t < 8.3$ ms)	I^2t	375									$A(rms)^2s$
Maximum Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +190									^oC

ELECTRICAL CHARACTERISTICS (All Types)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 12.0 Amps and Rated V_r, $T_C = 150^oC$, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
DC Forward Voltage Drop (I_F = 12.0 Adc, $T_C = 25^oC$)	V_F	1.0	Volts
Full Cycle Average Reverse Current (I_O = 12.0 Amps and Rated V_r, $T_C = 150^oC$, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, $T_C = 25^oC$)	I_R	0.5	mA

THERMAL CHARACTERISTICS

Maximum Steady State DC Thermal Resistance, $R_{\theta JC}$: 2.5°C/Watt

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

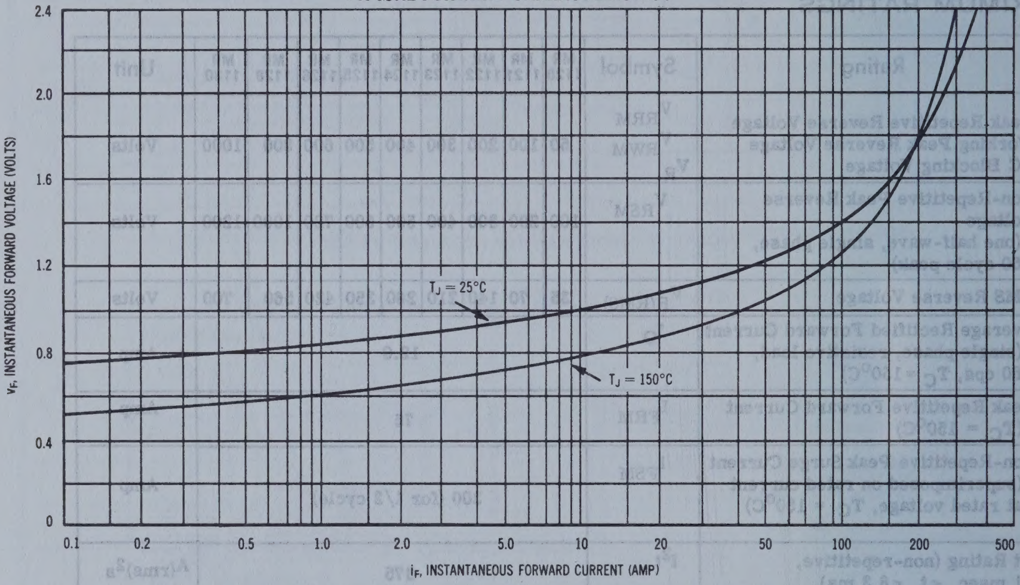
FINISH: All external surfaces corrosion-resistant and the terminal lug is readily solderable.

POLARITY: CATHODE-TO-CASE (reverse polarity units are available upon request and are designated by an "R" suffix i.e. MR1120R).

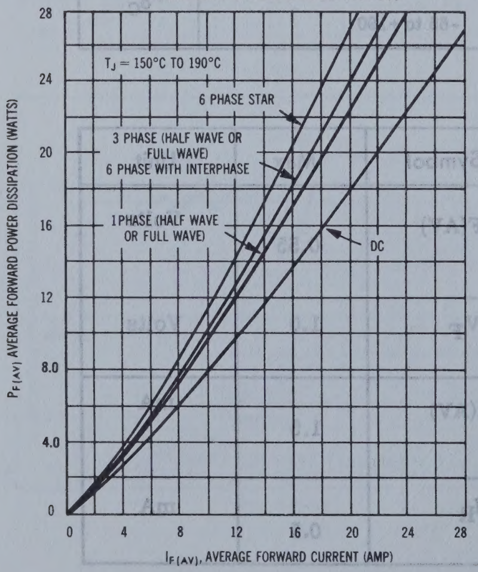
MOUNTING POSITIONS: Any

STUD TORQUE: 15 in-lbs maximum.

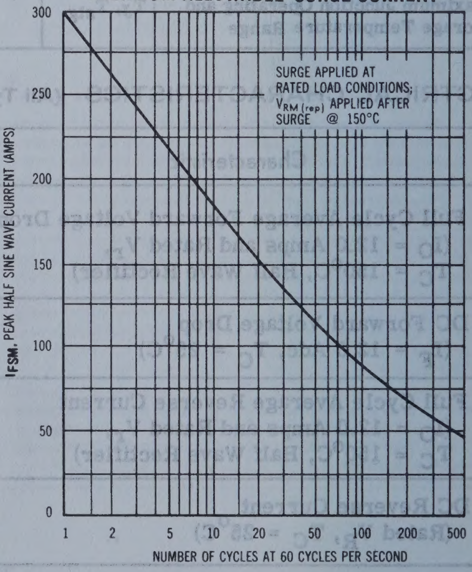
TYPICAL FORWARD CHARACTERISTICS



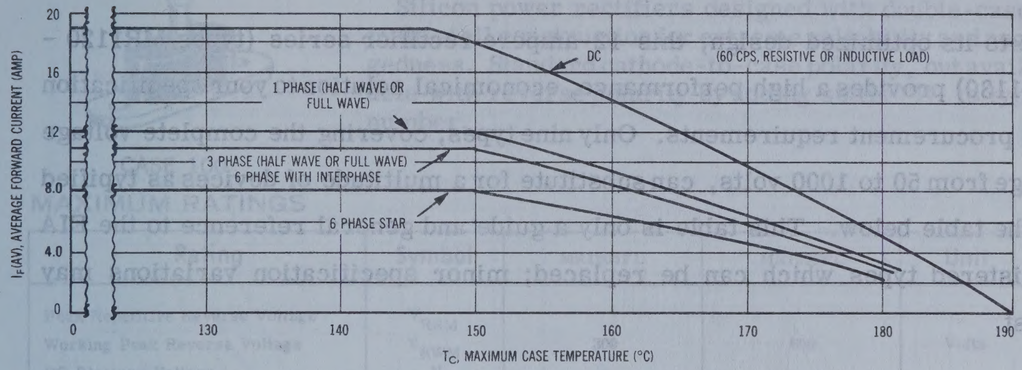
FORWARD POWER DISSIPATION



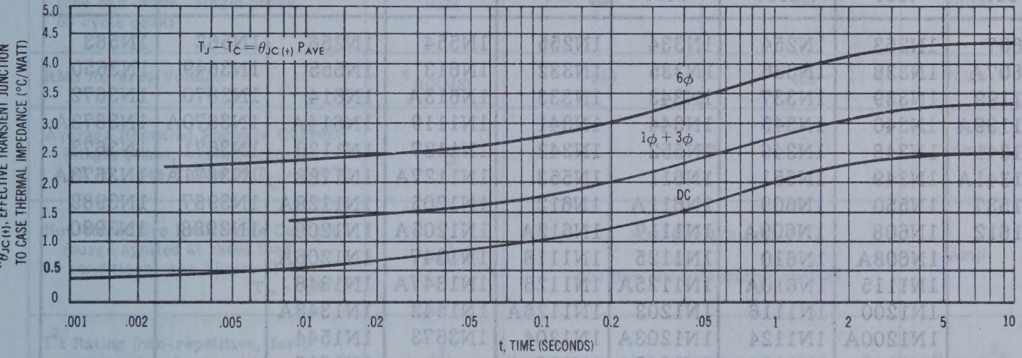
MAXIMUM ALLOWABLE SURGE CURRENT



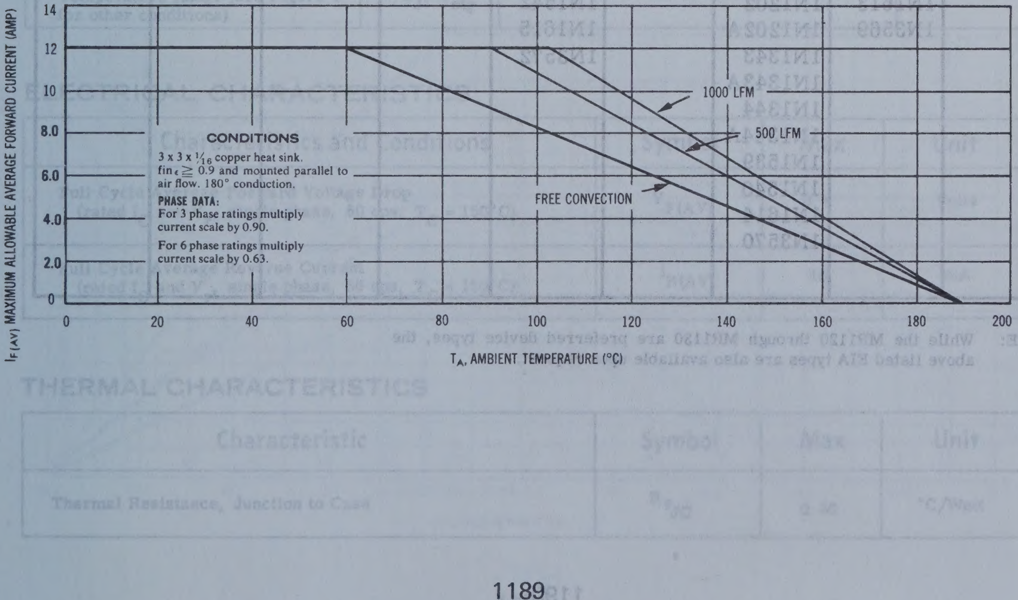
MAXIMUM CURRENT RATINGS



EFFECTIVE TRANSIENT THERMAL IMPEDANCE



CURRENT DERATING DATA



CONDITIONS

3 x 3 x $^1/_{16}$ copper heat sink. fin$_\epsilon \geqq$ 0.9 and mounted parallel to air flow. 180° conduction.

PHASE DATA: For 3 phase ratings multiply current scale by 0.90.

For 6 phase ratings multiply current scale by 0.63.

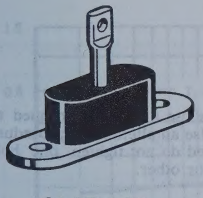
RECTIFIER SUBSTITUTION GUIDE

Due to its optimized design, this 12-ampere rectifier series (types MR1120 - MR1130) provides a high performance, economical solution to your specification and procurement requirements. Only nine types, covering the complete voltage range from 50 to 1000 volts, can substitute for a multitude of devices as typified in the table below. This table is only a guide and general reference to the EIA registered types which can be replaced; minor specification variations may exist.

MR1120 50V	MR1121 100V	MR1122 200V	MR1123 300V	MR1124 400V	MR1125 500V	MR1126 600V	MR1128 800V	MR1130 1000V
1N607	1N253	1N254	1N334	1N255	1N554	1N256	1N562	1N563
1N607A	1N338	1N336	1N335	1N332	1N613	1N555	1N3649	1N3650
1N1199	1N339	1N337	1N343	1N333	1N613A	1N614	1N3670	1N3672
1N1199A	1N340	1N345	1N344	1N341	1N1119	1N614A	1N3670A	1N3672A
1N1341	1N348	1N346	1N552	1N342	1N1127	1N1120	1N3671	1N3673
1N1341A	1N349	1N551	1N611	1N553	1N1127A	1N1128	1N3671A	1N3673A
1N1537	1N550	1N609	1N611A	1N612	1N1205	1N1128A	1N3987	1N3989
1N1612	1N608	1N609A	1N1117	1N612A	1N1205A	1N1206	1N3988	1N3990
	1N608A	1N610	1N1125	1N1118	1N1347	1N1206A		
	1N1115	1N610A	1N1125A	1N1126	1N1347A	1N1348		
	1N1200	1N1116	1N1203	1N1126A	1N1543	1N1348A		
	1N1200A	1N1124	1N1203A	1N1204	1N3573	1N1544		
	1N1342	1N1124A	1N1345A	1N1204A		1N1616		
	1N1342A	1N1201	1N1541	1N1346		1N3574		
	1N1538	1N1201A	1N3571	1N1346A				
	1N1613	1N1202		1N1542				
	1N3569	1N1202A		1N1615				
		1N1343		1N3572				
		1N1343A						
		1N1344						
		1N1344A						
		1N1539						
		1N1540						
		1N1614						
		1N3570						

NOTE: While the MR1120 through MR1130 are preferred device types, the above listed EIA types are also available upon request.

MR1205FL, MR1209FL (SILICON)



CASE 100

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR1205FL	MR1209FL	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RSM}	400	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	210	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz , see Figure 3) $T_C = 150°C$	I_O	50		Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5) $T_C = 150°C$	I_{FSM}	800 (for 1/2 cycle) 500 (for six consecutive cycles)		Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	1,300		$A_{(rms)}^2s$
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190		°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 cps, $T_C = 150°C$)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 cps, $T_C = 150°C$)	$I_{R(AV)}$	10	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.60	°C/Watt

MECHANICAL CHARACTERISTIC

PACKAGE CONFIGURATION:

MR1205FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE.
Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1205FLR.

MOUNTING POSITION: Any.

MOUNTING BOLT TORQUES:

Flat Mounted "FL" rectifiers use 8-32 bolts torqued to 30 in-lbs min., 40 in-lbs max. Use an alternating procedure when torquing the two bolts and do not tighten one bolt completely without tightening the other.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

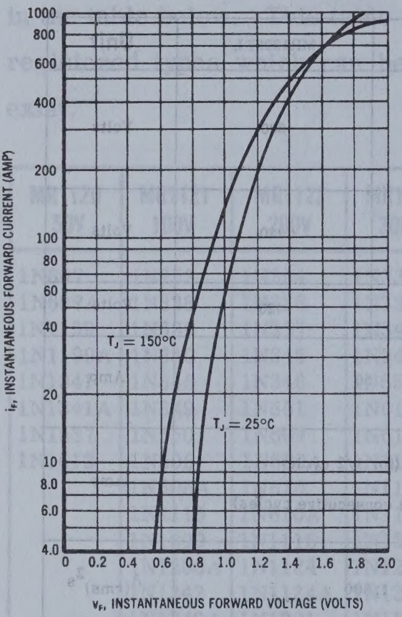


FIGURE 2 — FORWARD POWER DISSIPATION

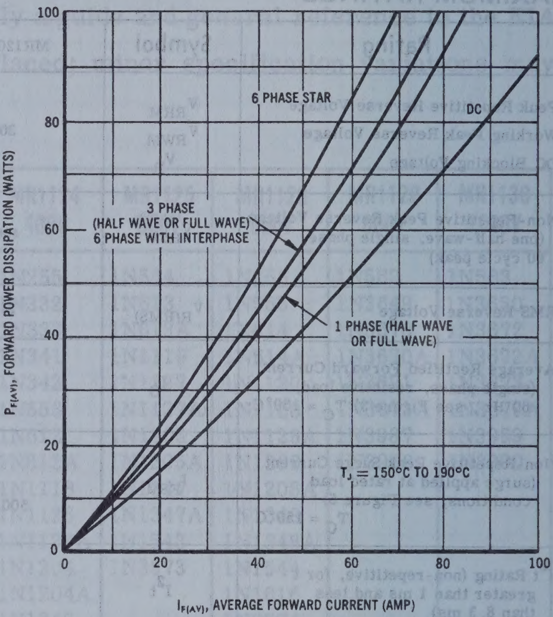


FIGURE 3 — MAXIMUM CURRENT RATINGS

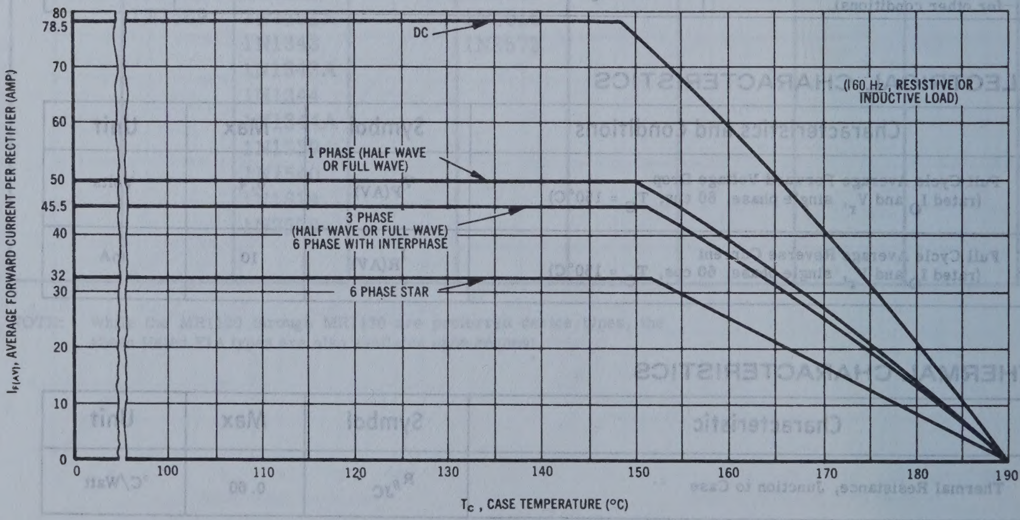


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

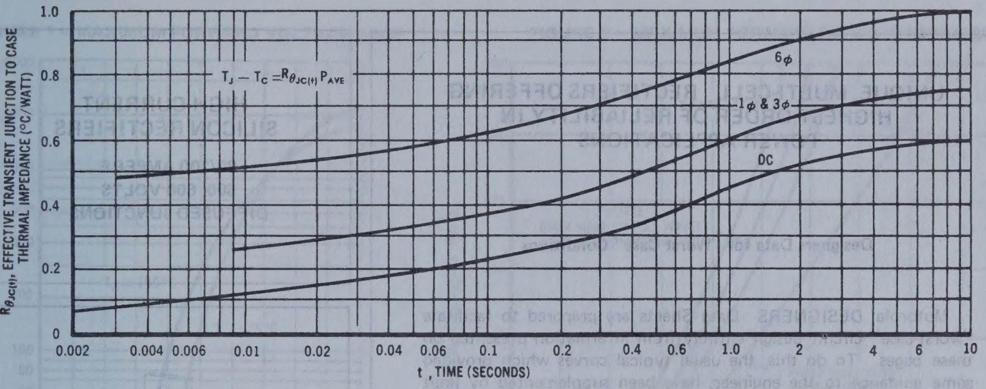
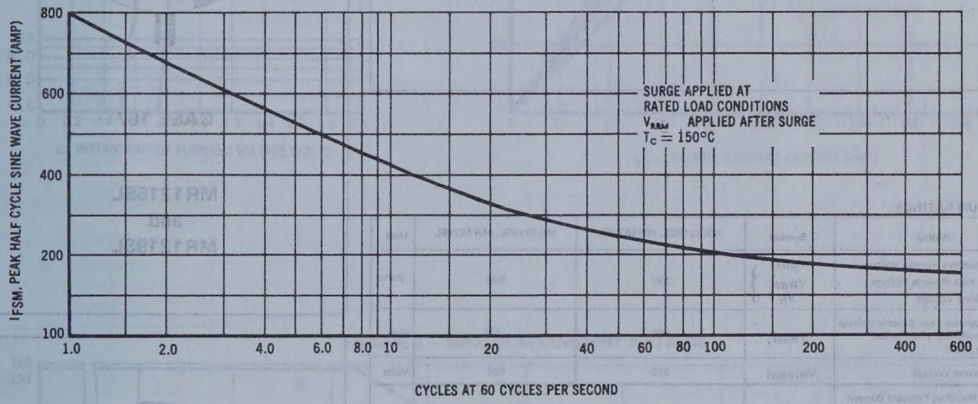
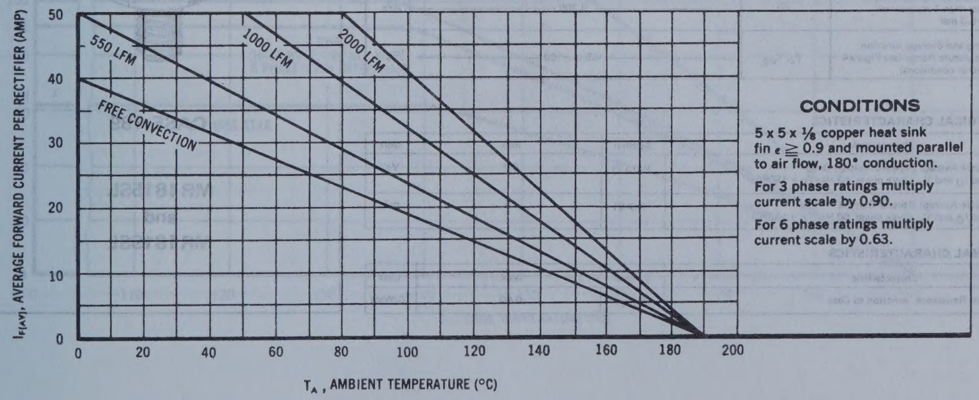


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT



SURGE APPLIED AT
RATED LOAD CONDITIONS
V_{RRM} APPLIED AFTER SURGE
$T_C = 150°C$

FIGURE 6 — CURRENT DERATING DATA



CONDITIONS

5 x 5 x ⅛ copper heat sink fin $\epsilon \geqq 0.9$ and mounted parallel to air flow, 180° conduction.

For 3 phase ratings multiply current scale by 0.90.

For 6 phase ratings multiply current scale by 0.63.

MR1215FL, MR1219FL (SILICON)
MR1815SL, MR1819SL

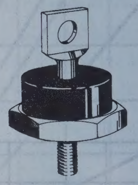
UNIQUE, MULTI-CELL RECTIFIERS OFFERING HIGHEST ORDER OF RELIABILITY IN POWER APPLICATIONS

Designers Data for "Worst Case" Conditions

Motorola DESIGNERS Data Sheets are prepared to facilitate "worst-case" circuit design entirely from information presented on these pages. To do this, the usual typical curves which provided some guidance to the engineer, have been supplemented by limit curves which are directly applicable to "worst-case" rectifier circuit design. Limit curves represent boundaries on parameters and does not necessarily indicate typical rectifier behavior.

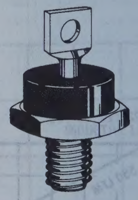
HIGH-CURRENT SILICON RECTIFIERS

80/100 AMPERE
300, 600 VOLTS
DIFFUSED JUNCTIONS



CASE 167

MR1215SL
and
MR1219SL



CASE 189

MR1815SL
and
MR1819SL

MAXIMUM RATINGS

Rating	Symbol	MR1215SL, MR1815SL	MR1219SL, MR1819SL	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 Hz peak)	V_{RSM}	400	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	210	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) $T_C = 135°C$ $T_C = 150°C$	I_O	100 80		Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) $T_C = 150°C$	I_{FSM}	2,000 (for 1/2 cycle) 1,200 (for six consecutive cycles)		Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	8,300		A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190		°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, $T_C = 150°C$)	$V_{F(AV)}$	0.4	Volt
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, $T_C = 150°C$)	$I_{R(AV)}$	15	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.40	°C/Watt

FIGURE 1 – MAXIMUM FORWARD VOLTAGE DROP

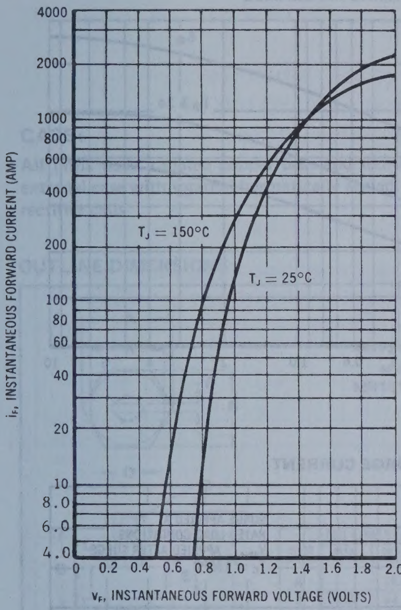


FIGURE 2 – MAXIMUM FORWARD POWER DISSIPATION

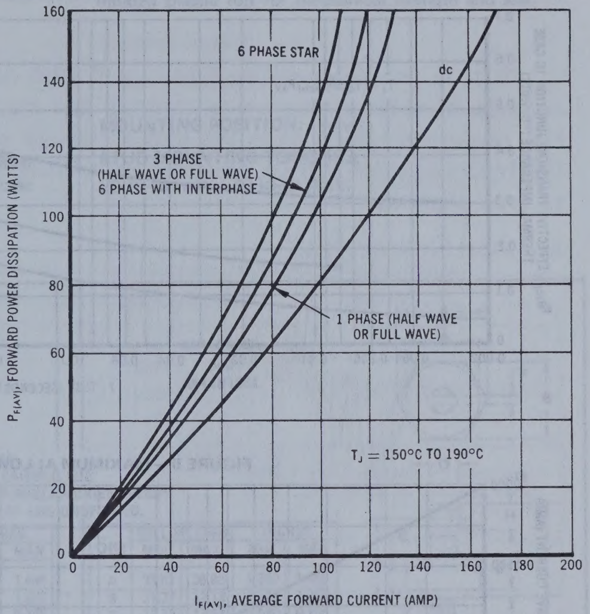


FIGURE 3 – MAXIMUM CURRENT RATINGS

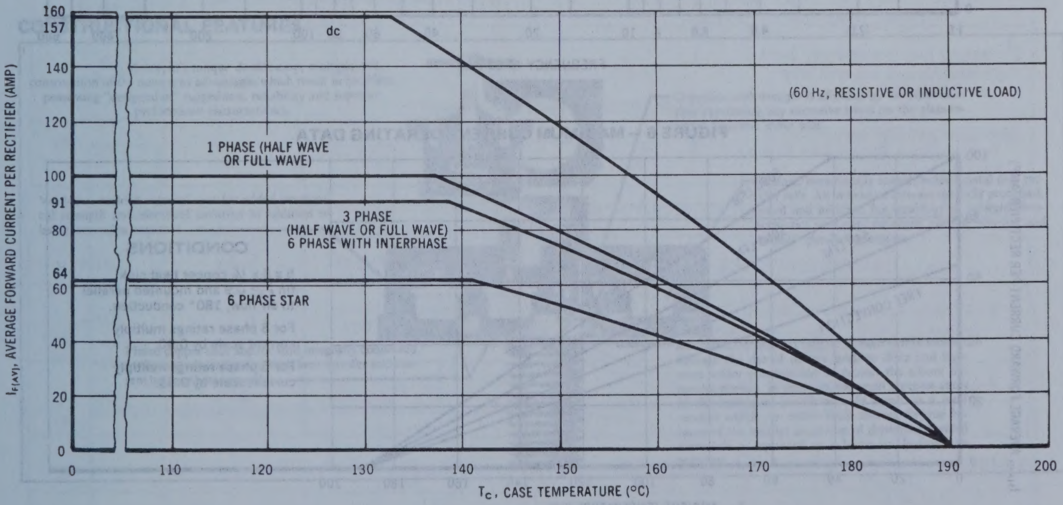


FIGURE 4 – EFFECTIVE TRANSIENT THERMAL IMPEDANCE

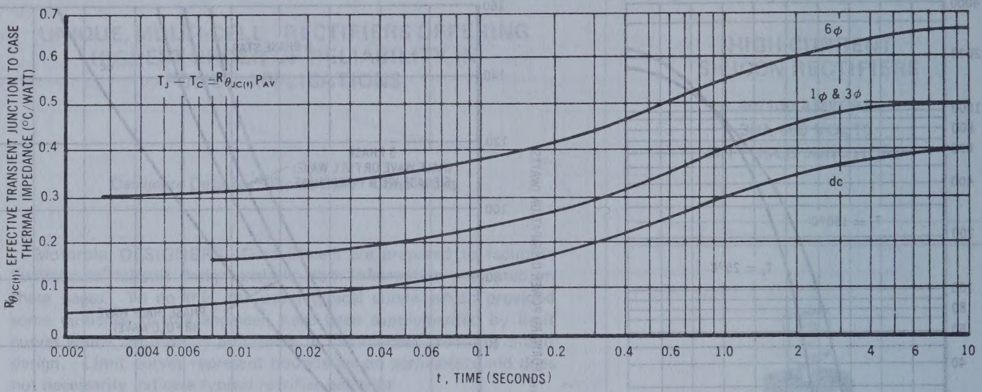


FIGURE 5 – MAXIMUM ALLOWABLE SURGE CURRENT

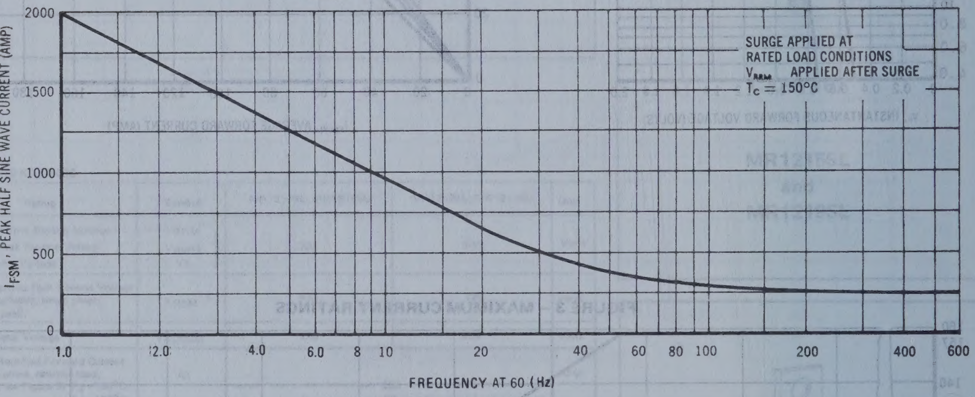
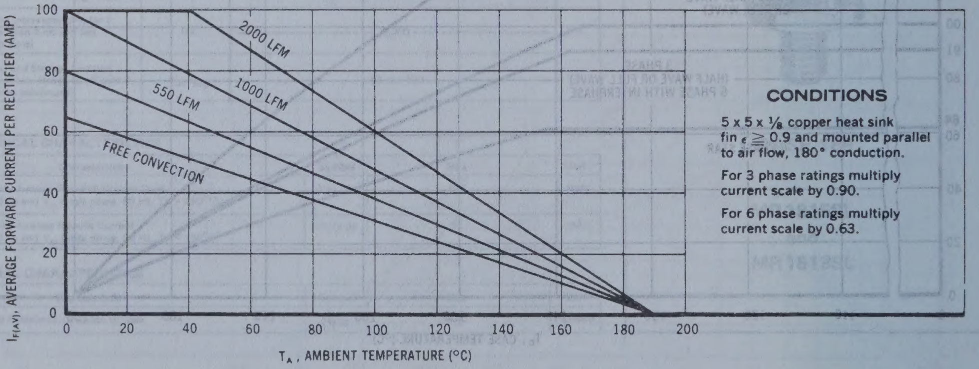


FIGURE 6 – MAXIMUM CURRENT DERATING DATA



CONDITIONS

5 x 5 x ⅛ copper heat sink fin $\epsilon \geqq 0.9$ and mounted parallel to air flow, 180° conduction.

For 3 phase ratings multiply current scale by 0.90.

For 6 phase ratings multiply current scale by 0.63.

POLARITY:

Standard polarity devices are CATHODE TO CASE. Reverse polarity devices are ANODE TO CASE and are designated by an "R" suffix i.e. MR1215SLR. These devices have a molded plastic top for mechanical strength and seal.

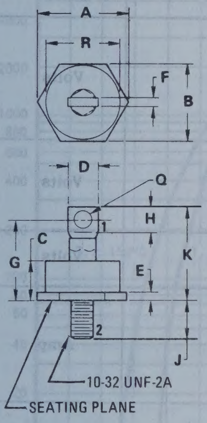
CASE:

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells

MOUNTING POSITION: Any

STUD MOUNTING TORQUES:
25 in-lb min., 30 in-lb max.

OUTLINE DIMENSIONS



CASE 167

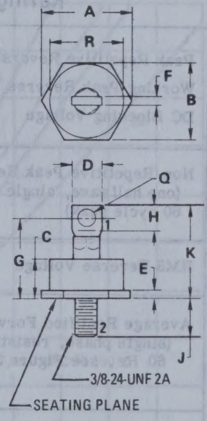
**MR1215SL
and
MR1219SL**

NOTES:
1. CRIMPED LUG
2. ANGULAR ORIENTATION OF LUG UNDEFINED.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	36.83	–	1.450
B	31.37	32.13	1.235	1.265
C	13.72	17.91	0.540	0.705
D	12.70	13.34	0.500	0.525
E	2.92	3.43	0.115	0.135
F	2.67	3.43	0.105	1.135
G	29.21	34.29	1.150	1.350
H	12.70	–	0.500	–
J	10.77	12.70	0.424	0.500
K	34.93	44.45	1.375	1.750
Q	6.10	6.60	0.240	0.260
R	–	30.48	–	1.200

**MR1815SL
and
MR1819SL**

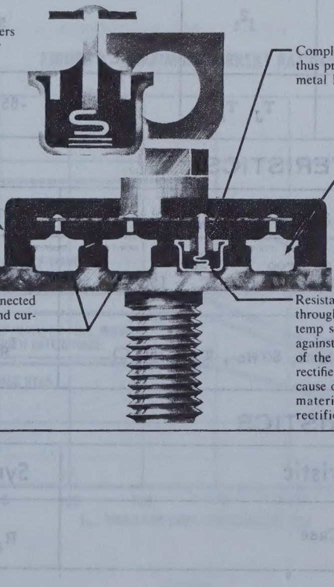
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	33.02	36.83	1.300	1.450
B	31.37	32.13	1.235	1.265
C	13.72	17.91	0.540	0.705
D	12.70	13.34	0.500	0.525
E	2.92	3.43	0.115	0.135
F	2.67	3.43	0.105	0.135
G	29.21	34.29	1.150	1.350
H	12.70	16.76	0.500	0.660
J	15.06	16.69	0.593	0.657
K	34.93	44.45	1.375	1.750
Q	6.10	6.60	0.240	0.260
R	–	30.48	–	1.200



CASE 189

CONSTRUCTIONAL FEATURES

Motorola's unique double-case, multiple cell construction offers numerous advantages which result in rectifiers possessing "designed-in" ruggedness, reliability and superior performance characteristics.



Complete seal strength is afforded by the outer case thus preventing any excessive stress on the glass-to-metal hermetic inner seal.

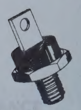
Void-free, molded external case for added mechanical strength and electrical isolation in addition to being corrosion resistant.

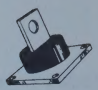
Internal, hermetically sealed, welded metal case rectifier cells. All individual cells are specially processed, tested and matched for similarity of forward characteristics to assure balanced current sharing and reliable parallel operation.

Plated copper base and/or stud integrally connected to the inner cases for optimum heat transfer and current balance between cells.

Resistance to thermal fatigue of each cell is assured through the use of double back-up discs and high temp solder construction to protect the silicon die against stresses. In addition, the small junction areas of the individual paralleled cells result in a total rectifier which can better resist thermal fatigue because of the smaller excursion of dissimilar bonded materials as opposed to a large single-junction rectifier.

MR1235FL, MR1239FL (SILICON)
MR1235SL, MR1239SL


SL CASE 127


FL CASE 134

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Available in two packages which have the same ratings and characteristics. Desired package can be selected by adding suffix "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR1235	MR1239	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	V_{RSM}	400	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	210	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) $T_C = 135°C$ $T_C = 150°C$	I_O	300 240		Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) $T_C = 150°C$	I_{FSM}	5,000 (for 1/2 cycle) 3,000 (for six consecutive cycles)		Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	52,000		A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190		°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and $V_{R(RMS)}$, single phase, 60 Hz, $T_C = 150°C$)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and $V_{R(RMS)}$, single phase, 60 Hz, $T_C = 150°C$)	$I_{R(AV)}$	35	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.12	°C/Watt

MECHANICAL CHARACTERISTICS

CASE:

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE. Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1235FLR.

MOUNTING POSITION: Any.

STUD AND MOUNTING BOLT TORQUES:

For Stud Mounted "SL" rectifiers, 300 in-lbs min., 400 in-lbs max.
For Flat Mounted "FL" rectifiers use ¼ inch bolts torqued to 60 in-lbs min., 80 in-lbs max. Use an alternating procedure when torquing the four bolts and do not tighten one bolt completely without tightening the others.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

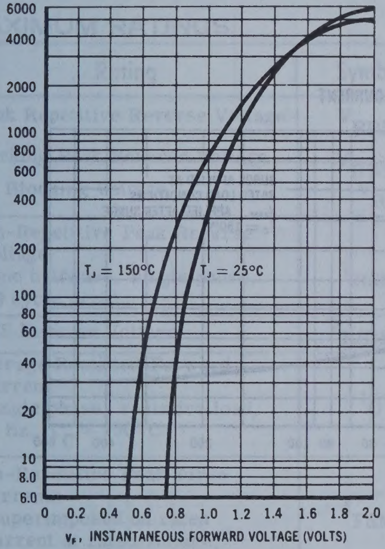


FIGURE 2 — FORWARD POWER DISSIPATION

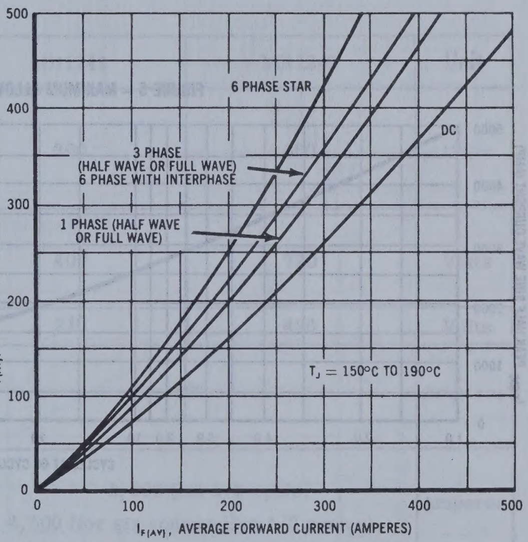


FIGURE 3 — MAXIMUM CURRENT RATINGS

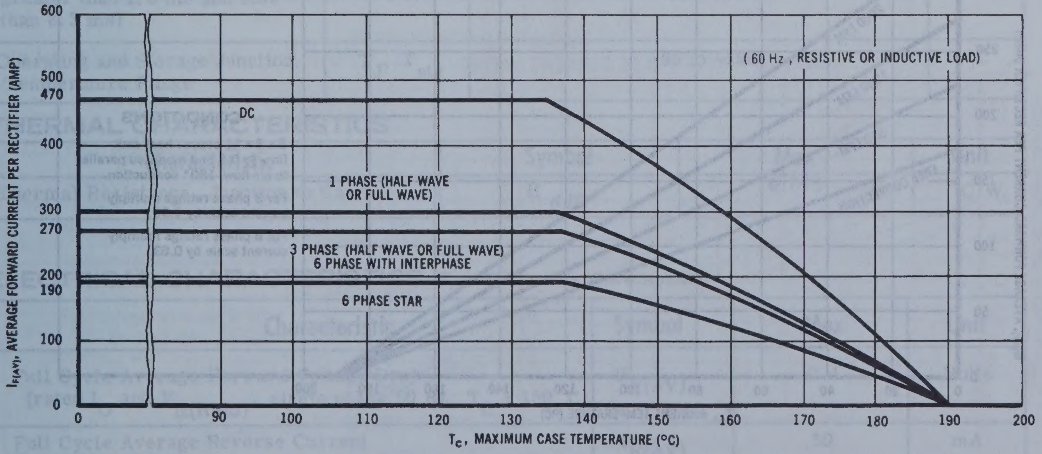


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

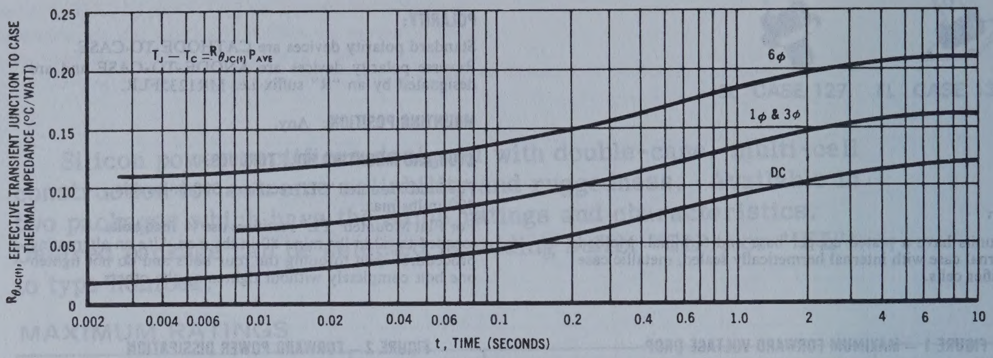


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

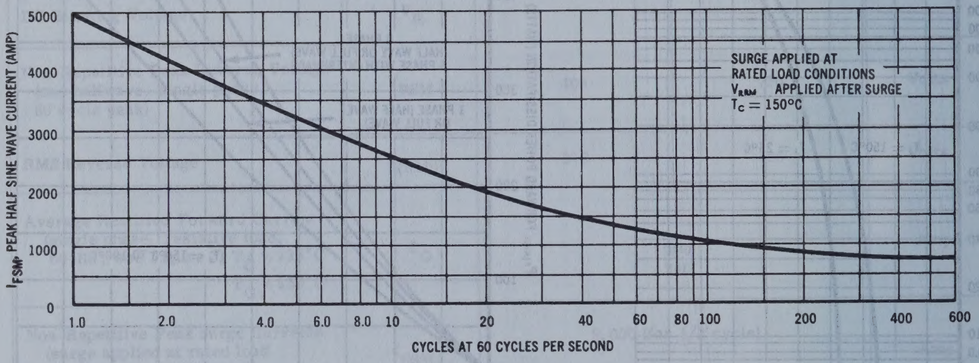
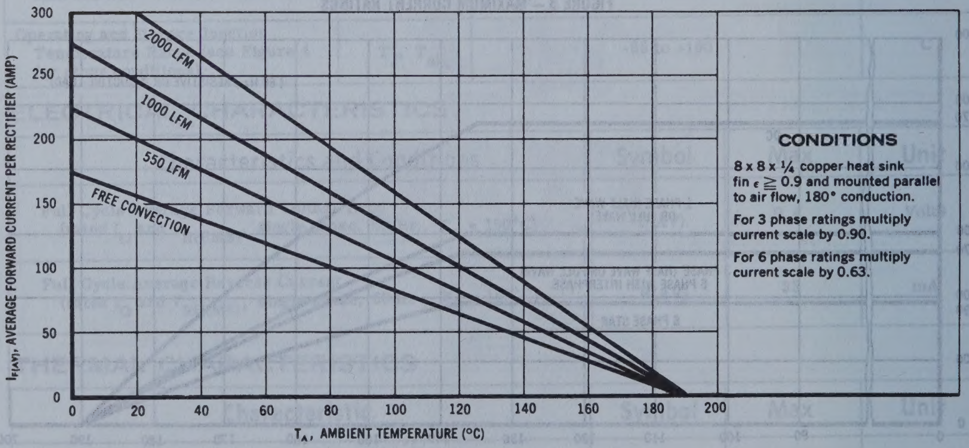
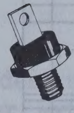


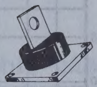
FIGURE 6 — CURRENT DERATING DATA



MR1245FL, MR1249FL (SILICON)
MR1245SL, MR1249SL



SL CASE 128



FL CASE 135

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Available in two packages which have the same ratings and characteristics. Desired package can be selected by adding suffix "SL" or "FL" to type number.

MAXIMUM RATINGS

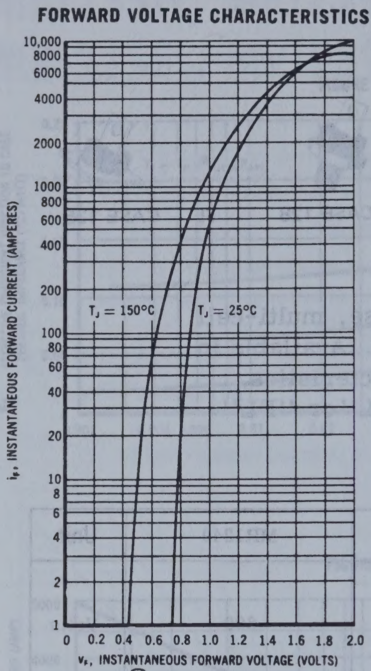
Rating	Symbol	MR1245	MR1249	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	V_{RSM}	400	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	210	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150° C)	I_O	400		Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150° C)	I_{FSM}	8, 000 (for 1/2 cycle) 4, 500 (for six consecutive 1/2 cycles)		Amperes
I^2t Rating (non-repetitive for t greater than 1.0 ms and less than 8.3 ms)	I^2t	133, 000		A^2s
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190		°C

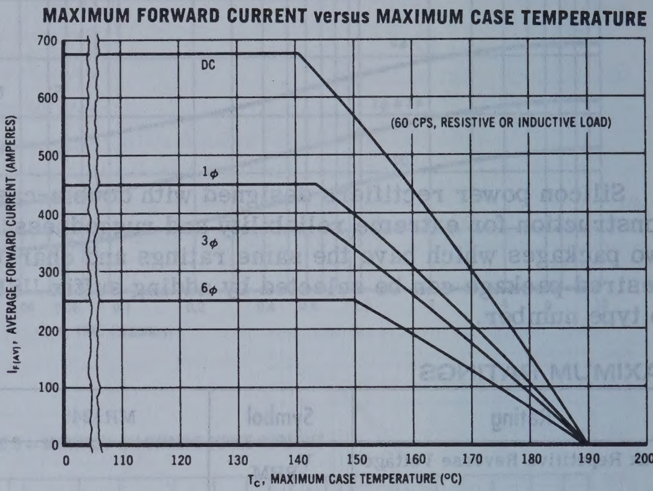
THERMAL CHARACTERISTICS

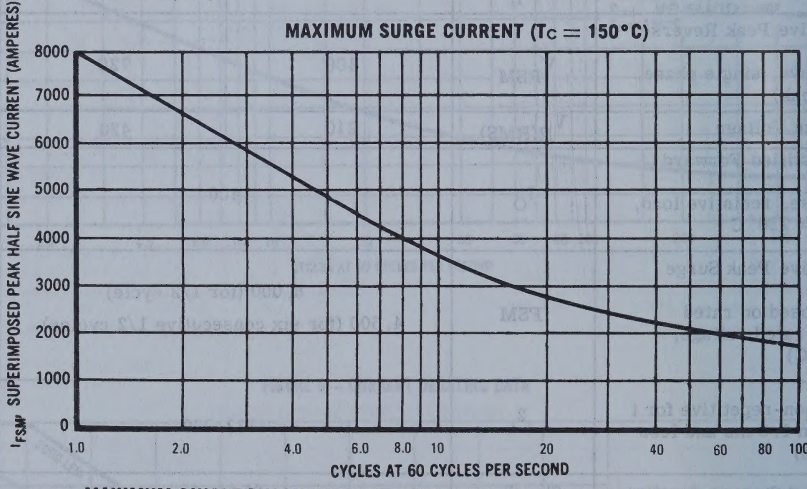
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.075	°C/W

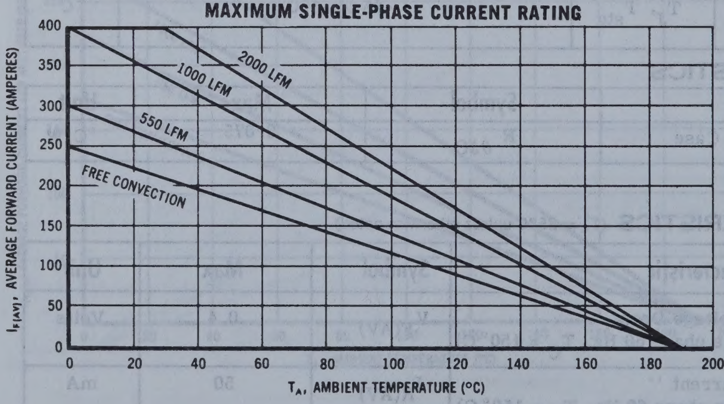
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and $V_{R(RMS)}$, single phase 60 Hz, T_C = 150° C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and $V_{R(RMS)}$, single phase 60 Hz, T_C = 150° C)	$I_{R(AV)}$	50	mA









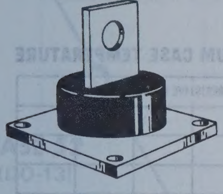
CONDITIONS

8 x 8 x ¼ copper heat sink fin∊ ≧ 0.9 and mounted parallel to air flow. 180° conduction.

For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1265FL, MR1269FL (SILICON)


CASE 136

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR1265	MR1269	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RSM}	400	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	210	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150° C)	I_O	650		Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150° C)	I_{FSM}	12,000 (for 1/2 cycle) 8,000 (for six consecutive 1/2 cycles)		Amperes
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	300,000		A^2s
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190		°C

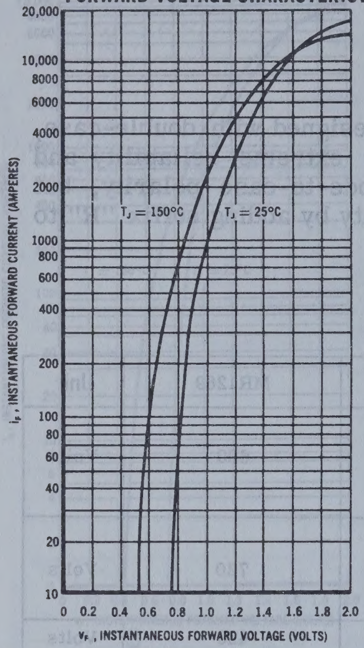
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.045	°C/Watt

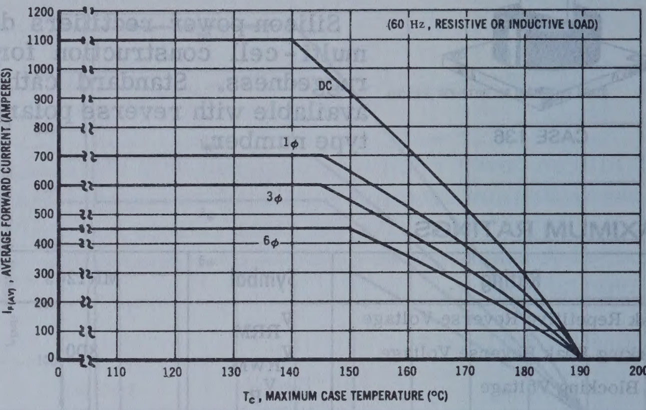
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and $V_{R(RMS)}$, single phase, 60 Hz, T_C = 150° C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and $V_{R(RMS)}$, single phase, 60 Hz, T_C = 150° C)	$I_{R(AV)}$	100	mA

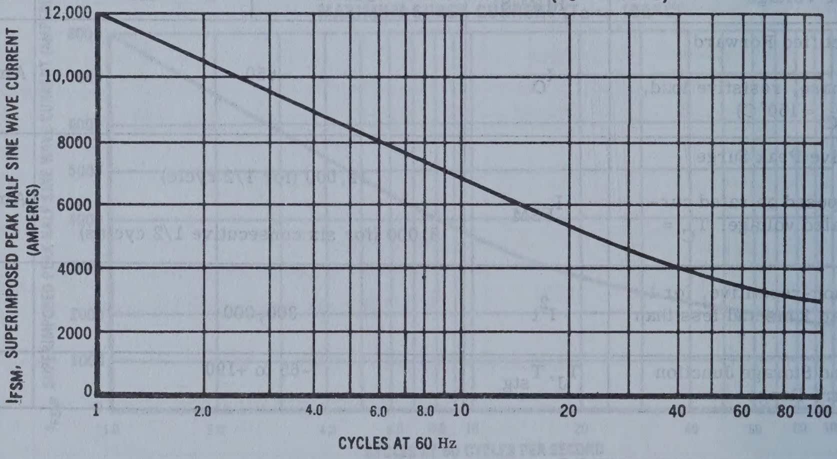
FORWARD VOLTAGE CHARACTERISTICS



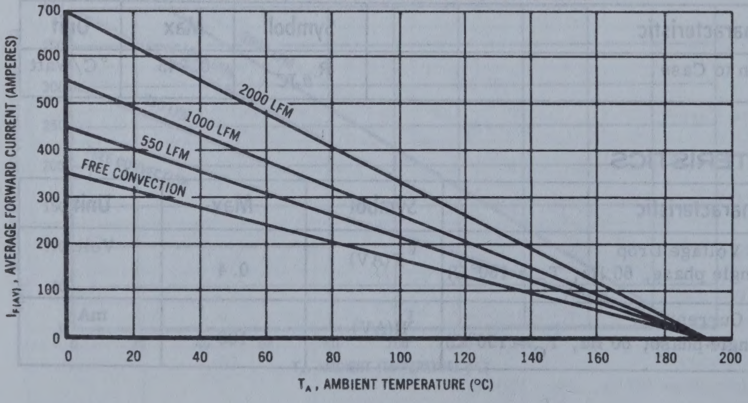
MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM SURGE CURRENT (T_C = 150°C)



MAXIMUM SINGLE-PHASE CURRENT RATING



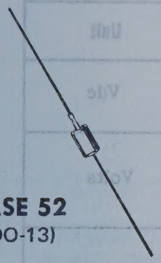
CONDITIONS

10 x 10 x ¼ copper heat sink fin $\epsilon \geqq 0.9$ and mounted parallel to air flow, 180° conduction.

For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1337-1 thru MR1337-5 (SILICON)



CASE 52
(DO-13)

Fast recovery silicon rectifiers designed for high-frequency power supply, inverter, and converter applications. Typical recovery time of 100 nsec extends practical frequency limit of current rectification to more than 300,000 Hz thus permitting the design of power supplies with smaller, lighter, and less expensive associated components.

MAXIMUM RATINGS

Rating	Symbol	MR 1337-1	MR 1337-2	MR 1337-3	MR 1337-4	MR 1337-5	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 cycle peak)	V_{RSM}	100	200	300	400	500	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Rectified Forward Current (single-phase resistive load) T_A=25°C Figure 2 T_A=75°C	I_O			1.0 0.75			Amp
Non-Repetitive Peak Surge Current Figure 3 (superimposed on rated current at rated voltage, T_A = 75 °C)	I_{FSM}			30			Amp
Peak Repetitive Forward Current (T_A = 75°C)	I_{FRM}			4.0			Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t			3.75			$A_{(rms)}^2s$
Maximum Junction Operating Temperature Range Maximum Case Storage Temperature Range	T_J T_{stg}			-65 to +150 -65 to +175			°C
Maximum Steady State DC Thermal Resistance	$R_{\theta JA}$			100			°C/Watt

FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS

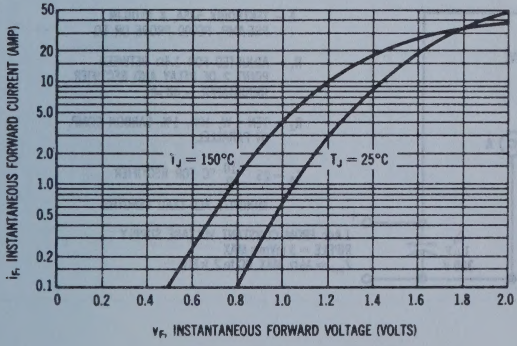
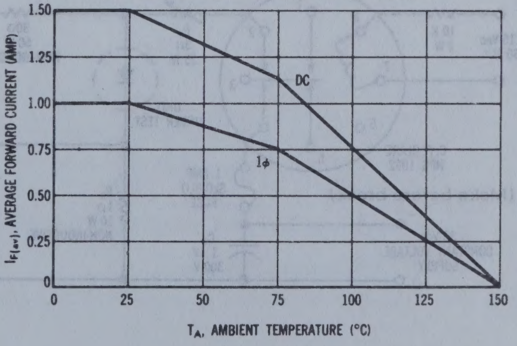


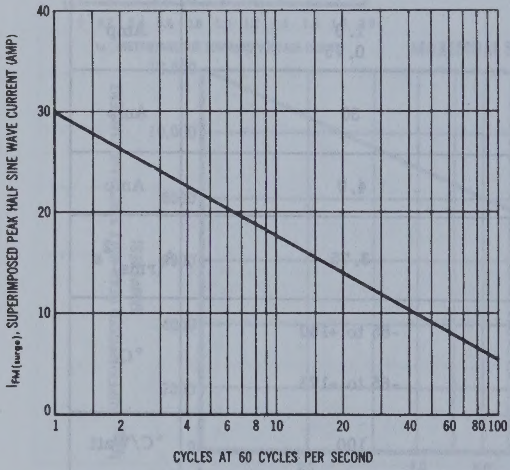
FIGURE 2 — MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM AMBIENT TEMPERATURE

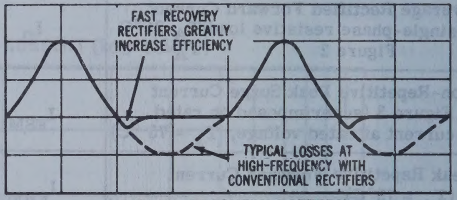


ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
DC Forward Voltage Drop (I_F = 1.0 Adc, T_A = 25°C)	V_F	1.1	Vdc
Full Cycle Average Forward Voltage Drop (I_O= 0.75 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
Full Cycle Average Reverse Current (I_O = 0.75 Amp and Rated V_r, T_A = 75°C, single phase)	$I_{R(AV)}$	0.75	mA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	0.25	mA
Maximum Reverse Recovery Time (I_F = 1 Amp min)	t_{rr}	200	ns
Maximum Overshoot Current	I_{os}	2.0	Amp

FIGURE 3 — MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT (SUPERIMPOSED ON RATED CONDITIONS, $V_{RM(rep)}$ APPLIED AFTER SURGE, $T_A = 75°C$)





TYPICAL RECOVERY PATTERN

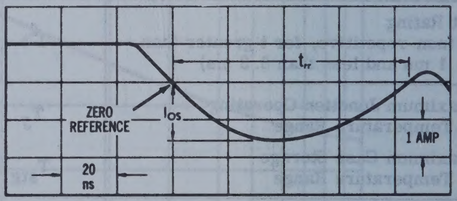
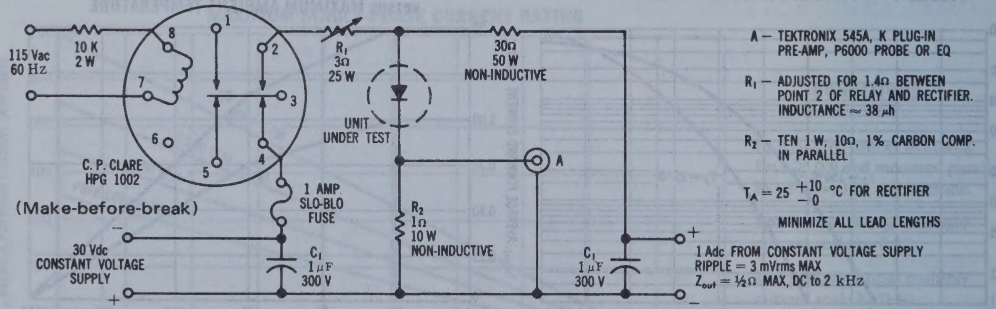


FIGURE 4 — t_{rr} TEST CIRCUIT



115 Vac 60 Hz
10 K 2 W
8
1
2
3
4
5
6
7
C. P. CLARE HPG 1002
(Make-before-break)
R_1 3Ω 25 W
30Ω 50 W NON-INDUCTIVE
UNIT UNDER TEST
A
1 AMP SLO-BLO FUSE
R_2 1Ω 10 W NON-INDUCTIVE
30 Vdc CONSTANT VOLTAGE SUPPLY
C_1 1 μF 300 V
C_1 1 μF 300 V
−
+
+
−

A — TEKTRONIX 545A, K PLUG-IN PRE-AMP, P6000 PROBE OR EQ

R_1 — ADJUSTED FOR 1.4Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER. INDUCTANCE ≈ 38 μh

R_2 — TEN 1 W, 10Ω, 1% CARBON COMP. IN PARALLEL

$T_A = 25 {}^{+10}_{-0}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = ½Ω MAX, DC to 2 kHz

MR1366

For Specifications, See 1N3879 Data, Volume 1.

MR1376

For Specifications, See 1N3889 Data, Volume 1.

MR1386

For Specifications, See 1N3899 Data, Volume 1.

MR1396

For Specifications, See 1N3909 Data, Volume 1.

MR1815SL (SILICON)
MR1819SL

For Specifications, See MR1215FL Data.

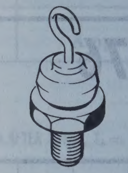
MR2000S SERIES (SILICON)

MEDIUM-CURRENT
SILICON RECTIFIERS
20 AMPERE
50-1000 VOLTS
DIFFUSED JUNCTION

MEDIUM-CURRENT SILICON RECTIFIERS

. . . compact, highly efficient silicon rectifiers for medium-current applications requiring:

- High Current Surge — 400 Amperes @ $T_J = 175^oC$
- Peak Performance @ Elevated Temperature — 20 Amperes @ $T_C = 150^oC$
- Low Cost
- Compact, Molded Package — For Optimum Efficiency in a Small Case Configuration.



MAXIMUM RATINGS

Characteristic	Symbol	MR 2000S	MR 2001S	MR 2002S	MR 2004S	MR 2006S	MR 2008S	MR 2010S	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz peak)	V_{RSM}	60	120	240	480	720	960	1200	Volts
RMS Forward Current	$I_{(RMS)}$	← 40 →							Amp
Average Rectified Forward Current (Single phase, resistive load, 60 Hz, $T_C = 150^oC$)	I_O	← 20 →							Amp
Non-Repetitive Peak Surge Current (surge applied @ rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	← 400 (for 1 cycle) →							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →							^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.3	$^oC/W$

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage ($i_F = 63$ Amp, $T_C = 25^oC$)	v_F	1.1	Volts
Maximum Reverse Current (rated dc voltage) $T_C = 25^oC$ $T_C = 100^oC$	I_R	100 500	µA

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded.

FINISH: All External Surfaces are Corrosion-Resistant and the Terminal Lead is Readily Solderable.

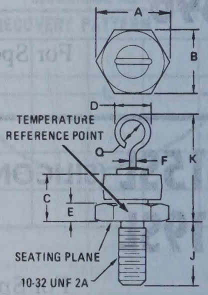
POLARITY: Cathode to Case (Reverse Polarity Units are Available and Designated by an "R" Suffix i.e., MR2000SR).

MOUNTING POSITIONS: Any

STUD TORQUE: 15 in. lbs. Maximum

MAXIMUM TERMINAL TEMPERATURE FOR SOLDERING PURPOSES: 275°C for 10 Seconds @ 3 Kg Tension.

WEIGHT: 6 Grams (Approximately).



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.12	12.70	0.477	0.500
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.19	1.35	0.047	0.053
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
Q	1.52	–	0.060	–

CASE 283-01
DO-4

FIGURE 1 – FORWARD VOLTAGE

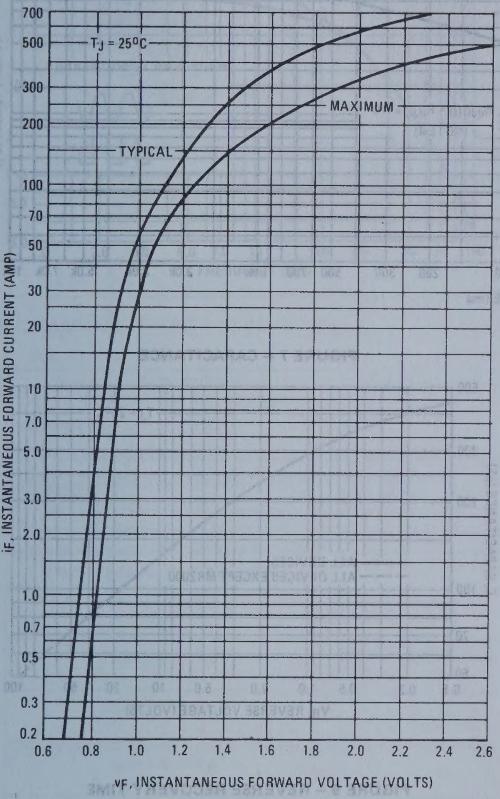


FIGURE 2 – NON-REPETITIVE SURGE CURRENT

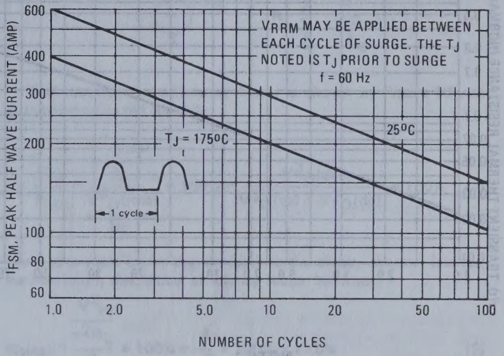


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

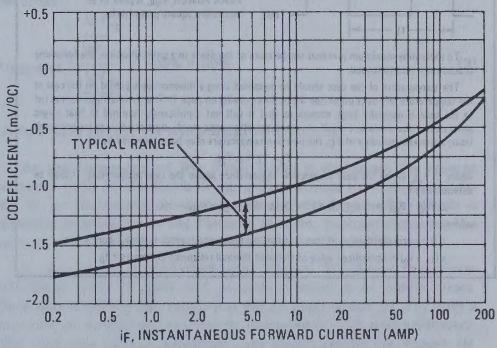


FIGURE 4 – CURRENT DERATING

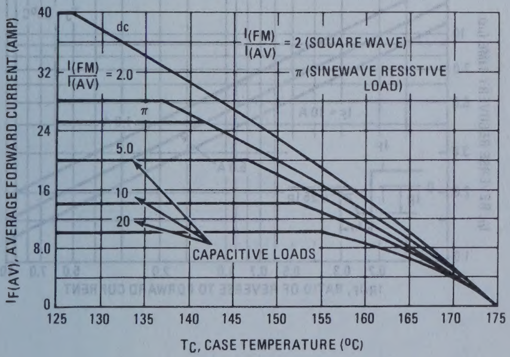


FIGURE 5 – FORWARD POWER DISSIPATION

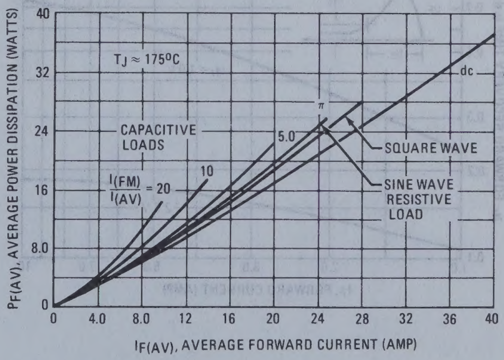
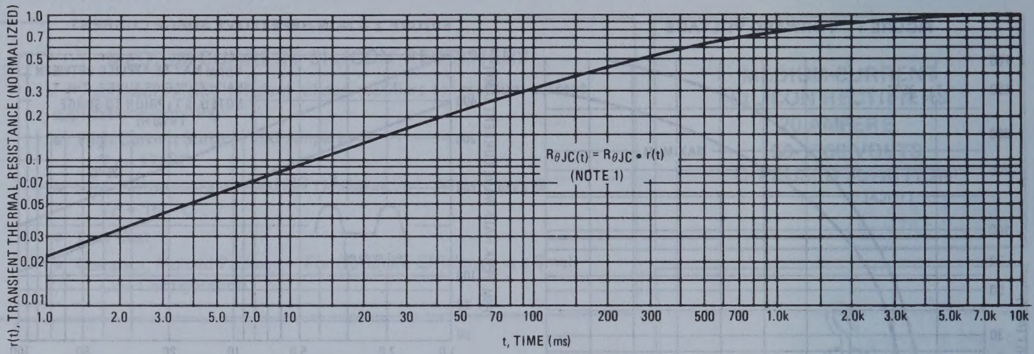
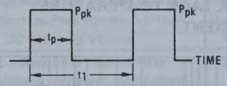


FIGURE 6 – THERMAL RESPONSE



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended.

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see the outline drawing on page 1). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \bullet R_{\theta JC} [D + (1 - D) \bullet r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.,

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 7 – CAPACITANCE

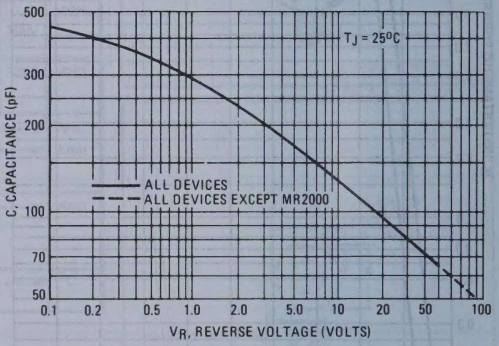


FIGURE 8 – FORWARD RECOVERY TIME

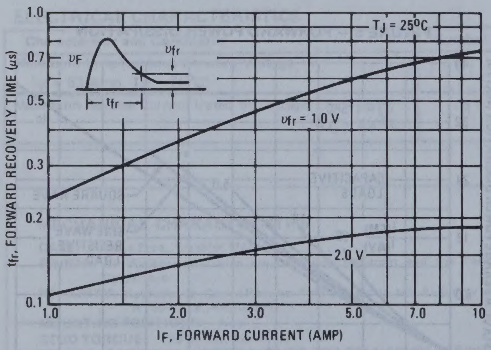


FIGURE 9 – REVERSE RECOVERY TIME

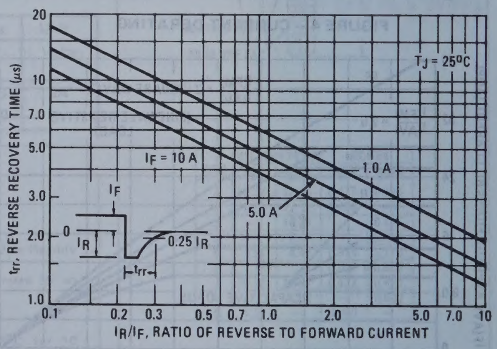
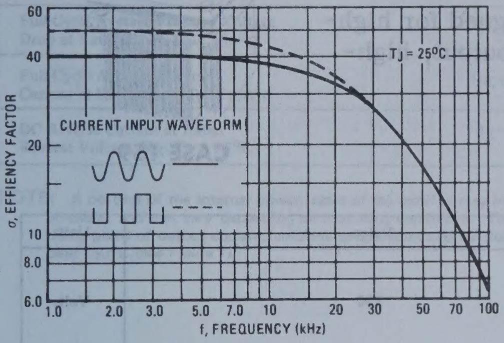
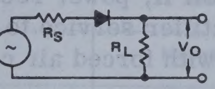


FIGURE 10 – RECTIFICATION WAVEFORM EFFICIENCY



RECTIFICATION EFFICIENCY NOTE

FIGURE 11 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 10 was calculated using the formula:

$$\sigma = \frac{P_{dc}}{P_{rms}} = \frac{\dfrac{V^2{}_{O(dc)}}{R_L}}{\dfrac{V^2{}_{O(rms)}}{R_L}} \bullet 100\% = \frac{V^2{}_{O(dc)}}{V^2{}_{O(ac)} + V^2{}_{O(dc)}} \bullet 100\% \qquad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assume lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\dfrac{V^2{}_m}{\pi^2 R_L}}{\dfrac{V^2{}_m}{4R_L}} \bullet 100\% = \frac{4}{\pi^2} \bullet 100\% = 40.6\% \qquad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

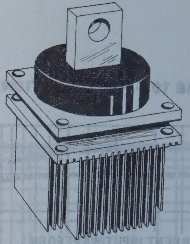
$$\sigma_{(square)} = \frac{\dfrac{V^2{}_m}{2R_L}}{\dfrac{V^2{}_m}{R_L}} \bullet 100\% = 50\% \qquad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 9) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 10.

It should be emphasized that Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_O with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.

MR2083HA (SILICON)



CASE 159

Multi-cell II, power rectifier diode designed for high-current rectifier service to provide single-output, high-current dc with forced air cooling.

MAXIMUM DIODE RATINGS

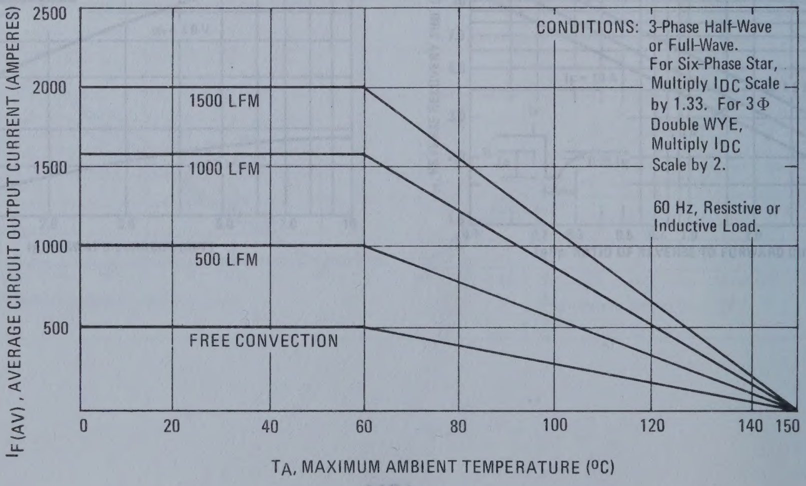
Rating	Symbol	Value	Units
Peak Repetitive Reverse Voltage	V_{RRM}	300	Volts
Working Peak Reverse Voltage	V_{RWM}		
DC Blocking Voltage	V_R		
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	V_{RSM}	400	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, $T_C = 150°C$)	I_O	750	Amperes
Non-Repetitive Surge Currents at Rated Conditions	I_{FSM}	12,000 for 1/2 cycle 8,000 for 6 cycles	Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	3 Diodes Either Polarity	2,000 Amperes
Three-Phase Full-Wave (6-1-1-B)	6 Diodes Either Polarity or 3 Diodes Each Polarity	2,000 Amperes
Six-Phase Star (6-1-1-S)	6 Diodes Either Polarity	2,600 Amperes
Six-Phase with Interphase, 3 Φ Double WYE (6-1-1-Y)	6 Diodes Either Polarity	4,000 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

FIGURE 1 – MAXIMUM CIRCUIT RATINGS



ELECTRICAL CHARACTERISTICS (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	80	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	4.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

MECHANICAL CHARACTERISTICS

POLARITY:

Standard polarity devices are CATHODE-TO-CASE, reverse polarity devices are ANODE-TO-CASE and designated by an "R" suffix, i.e., MR2083HAR.

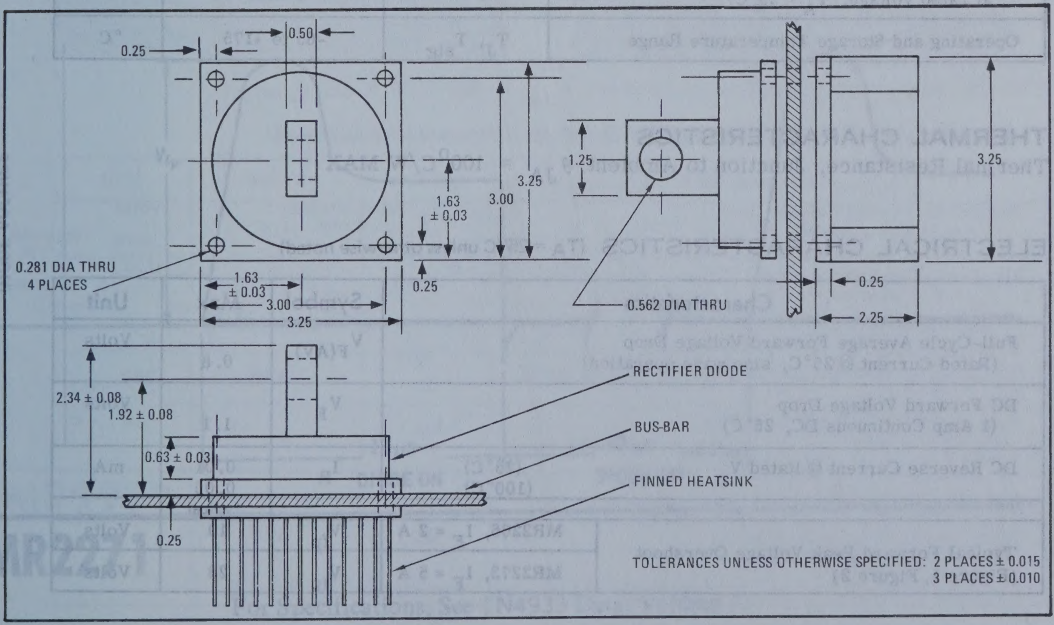
MOUNTING POSITION:

Cooling fins vertical for convection cooling or parallel to forced air flow.

MOUNTING CONFIGURATION:

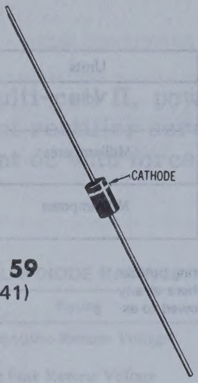
The MR2083HA is designed to be mounted as an integral part of the current carrying bus-bar network of the rectifier system as shown in the outline dimensions. The rectifier diode and finned heatsink are supplied as two separate pieces under one common type number.

OUTLINE DIMENSIONS


0.50
0.25
3.25
3.00
1.63
± 0.03
0.25
0.281 DIA THRU
4 PLACES
1.63
± 0.03
3.00
3.25
1.25
0.562 DIA THRU
3.25
0.25
2.25
2.34 ± 0.08
1.92 ± 0.08
0.63 ± 0.03
0.25
RECTIFIER DIODE
BUS-BAR
FINNED HEATSINK

TOLERANCES UNLESS OTHERWISE SPECIFIED: 2 PLACES ± 0.015
3 PLACES ± 0.010

MR2266 (SILICON)
MR2273



CASE 59
(DO-41)

High-voltage, axial-lead, silicon rectifiers, designed for television "damper" diode service, feature subminiature packages, high current-handling capability, excellent reliability, and economy. Flame-proof silicone polymer case.

MAXIMUM RATINGS

Rating	Symbol	MR2273	MR2266	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	200	800	Volts
RMS Reverse Voltage (Sine wave operation)	$V_{R(RMS)}$	140	560	Volts
Average Rectified Forward Current (single-phase, resistive load, 60 Hz) (75°C Ambient) (100°C Ambient)	I_O	1.0 0.75	1.0 0.75	Amp
Peak Repetitive Forward Current ($T_A = 25°C$)	I_{FRM}	10		Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_A = 25°C$)	I_{FSM}	30 (for 1/2 cycle)		Amp
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175		°C

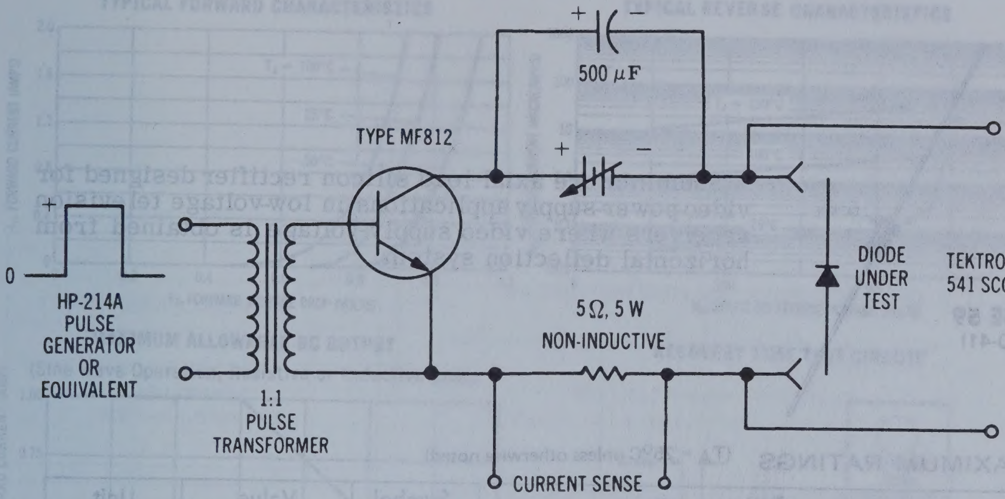
THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: $\theta_{JA} = 100°C/W$ MAX

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics		Symbol	Max	Unit
Full-Cycle Average Forward Voltage Drop (Rated Current @ 25°C, sine wave operation)		$V_{F(AV)}$	0.8	Volts
DC Forward Voltage Drop (1 Amp Continuous DC, 25°C)		V_F	1.1	Volts
DC Reverse Current @ Rated V_r	(25°C) (100°C)	I_R	0.01 0.05	mA
			Typical	
Typical Forward Peak Voltage Overshoot (Figure 1, Figure 2)	MR2266, $I_F = 2$ A	V_{fp}	10	Volts
	MR2273, $I_F = 5$ A	V_{fp}	28	Volts

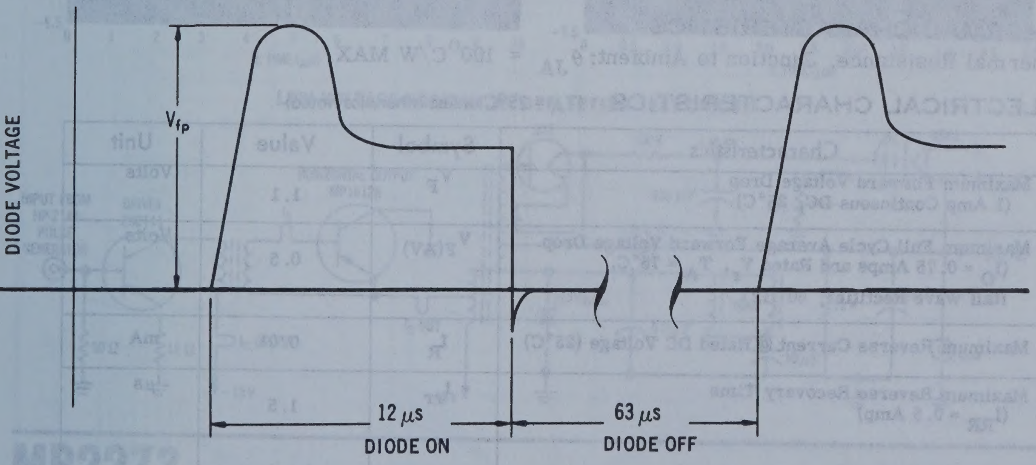
FIGURE 1 — FORWARD PEAK VOLTAGE OVERSHOOT TEST CIRCUIT


+
0
HP-214A PULSE GENERATOR OR EQUIVALENT
1:1 PULSE TRANSFORMER
TYPE MF812
+ −
500 μF
+ −
5 Ω, 5 W NON-INDUCTIVE
CURRENT SENSE
DIODE UNDER TEST
TEKTRONIX 541 SCOPE

TEST PROCEDURE:

1. Adjust input pulse from generator to saturate MF812 transistor
2. Adjust battery voltage for the specified forward current after the voltage overshoot.
   I_F = 2 Amps, for MR2266
   I_F = 5 Amps, for MR2273
3. Read peak voltage overshoot across diode under test. (See Waveform Diagram).

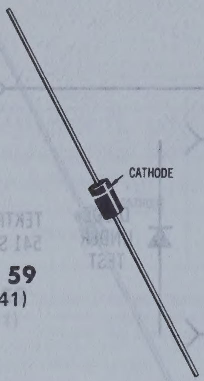
FIGURE 2 — DIODE UNDER TEST, WAVEFORM DIAGRAM


DIODE VOLTAGE
V_{fp}
12 μs
DIODE ON
63 μs
DIODE OFF

MR2271

For Specifications, See 1N4933 Data, Volume 1.

MR2272 (SILICON)



CASE 59
(DO-41)

Subminiature axial-lead silicon rectifier designed for video power-supply applications in low-voltage television receivers where video supply-voltage is obtained from horizontal deflection system.

MAXIMUM RATINGS (T$_A$ = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	400	Volts
RMS Reverse Voltage (Sine wave operation)	$V_{R(RMS)}$	280	Volts
Average Rectified Forward Current (Sine wave operation) (75°C Ambient) (100°C Ambient)	I_O	1.0 0.75	Amp
Peak Repetitive Forward Current (T_A = 75°C)	I_{FRM}	10	Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C)	I_{FSM}	30 (for 1/2 cycle) @ 60 Hz	Amp
Juction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175	°C

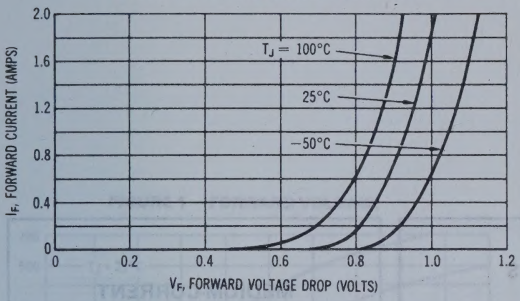
THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: θ_{JA} = 100°C/W MAX

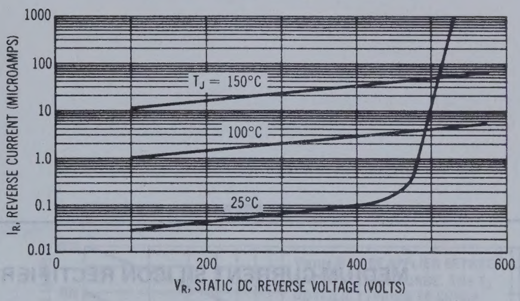
ELECTRICAL CHARACTERISTICS (T$_A$ = 25°C unless otherwise noted)

Characteristics	Symbol	Value	Unit
Maximum Forward Voltage Drop (1 Amp Continuous DC, 25°C)	V_F	1.1	Volts
Maximum Full Cycle Average Forward Voltage Drop (I_O = 0.75 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier, 60 Hz)	$V_{F(AV)}$	0.5	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C)	I_R	0.01	mA
Maximum Reverse Recovery Time (I_{RR} = 0.5 Amp)	t_{rr}	1.5	µs
Rectification Efficiency (Typical)	RE	55	%

TYPICAL FORWARD CHARACTERISTICS

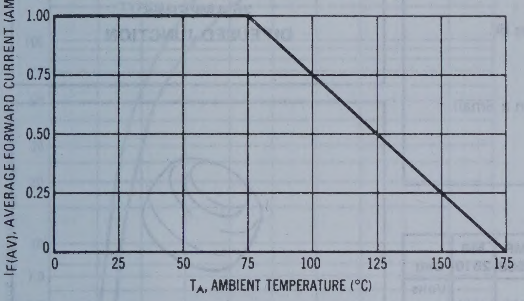


TYPICAL REVERSE CHARACTERISTICS

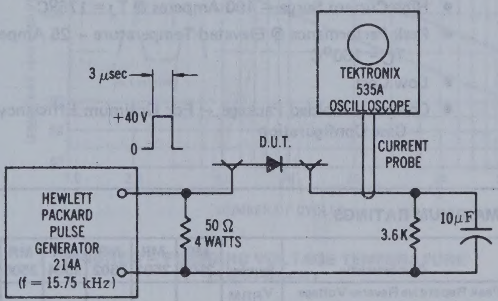


MAXIMUM ALLOWABLE DC OUTPUT

(Sine Wave Operation, Resistive or Inductive Load)

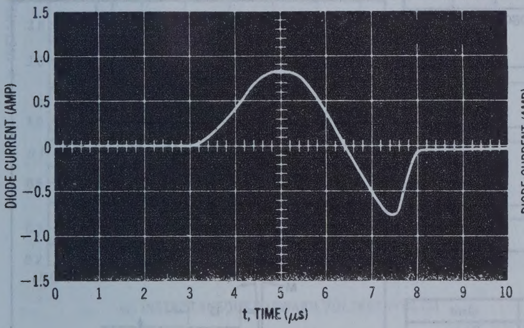


RECOVERY TIME TEST CIRCUIT

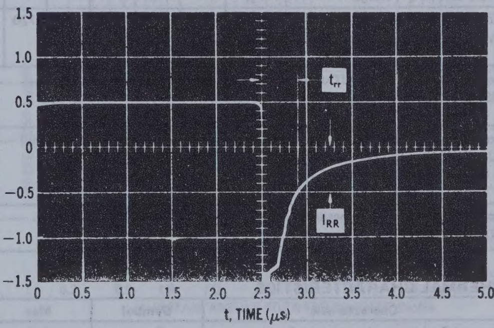


3 μsec
+40 V
0
TEKTRONIX
535A
OSCILLOSCOPE
D.U.T.
CURRENT
PROBE
HEWLETT
PACKARD
PULSE
GENERATOR
214A
(f = 15.75 kHz)
50 Ω
4 WATTS
3.6 K
10 μF

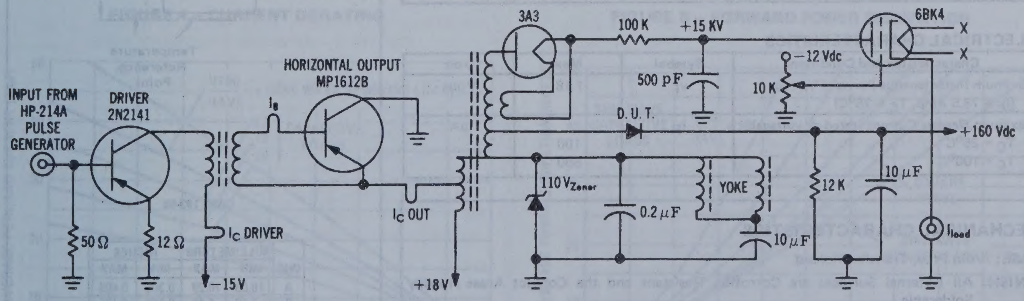
DIODE CURRENT WAVEFORM IN VIDEO SUPPLY OPERATION



TYPICAL RECOVERY WAVEFORM IN CIRCUIT



LOW VOLTAGE HORIZONTAL DEFLECTION TEST CIRCUIT



3A3
100 K
+15 KV
6BK4
X
X
500 pF
−12 Vdc
10 K
HORIZONTAL OUTPUT
MP1612B
INPUT FROM
HP-214A
PULSE
GENERATOR
DRIVER
2N2141
I_B
D. U. T.
+160 Vdc
110 V_{Zener}
0.2 μF
YOKE
12 K
10 μF
I_{load}
10 μF
I_C OUT
50 Ω
12 Ω
I_C DRIVER
−15 V
+18 V

MR2273 (SILICON)

For Specifications, See MR2266 Data.

MR2500 SERIES (SILICON)

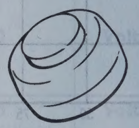
MEDIUM-CURRENT SILICON RECTIFIERS

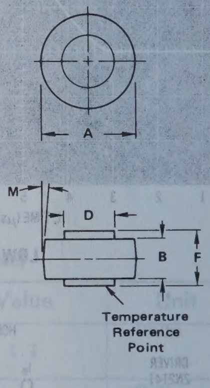
. . . compact, highly efficient silicon rectifiers for medium-current applications requiring:

- High Current Surge — 400 Amperes @ T_J = 175°C
- Peak Performance @ Elevated Temperature — 25 Amperes @ T_C = 150°C
- Low Cost
- Compact, Molded Package — For Optimum Efficiency in a Small Case Configuration

MEDIUM-CURRENT SILICON RECTIFIERS

50 – 1000 VOLTS
25 AMPERES
DIFFUSED JUNCTION





CASE 193-03

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.03	10.29	0.395	0.405
B	4.19	4.45	0.165	0.175
D	5.54	5.64	0.218	0.222
F	5.94	6.25	0.234	0.246
M	5° NOM		5° NOM	

MAXIMUM RATINGS

Characteristic	Symbol	MR 2500	MR 2501	MR 2502	MR 2504	MR 2506	MR 2508	MR 2510	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz peak)	V_{RSM}	60	120	240	480	720	960	1200	Volts
Average Rectified Forward Current (Single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	← 25 →							Amp
Non-Repetitive Peak Surge Current (surge applied @ rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	← 400 (for 1 cycle) →							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +175 →							°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case (Single Side Cooled)	$R_{\theta JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage (i_F = 78.5 Amp, T_C = 25°C)	v_F	1.18	Volts
Maximum Reverse Current (rated dc voltage) T_C = 25°C T_C = 100°C	I_R	 100 500	µA

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded.

FINISH: All External Surfaces are Corrosion Resistant and the Contact Areas Readily Solderable.

POLARITY: Indicated by dot on Cathode Side

MOUNTING POSITIONS: Any

MAXIMUM TEMPERATURE FOR SOLDERING PURPOSES: 250°C

WEIGHT: 1.8 Grams (Approximately)

FIGURE 1 — FORWARD VOLTAGE

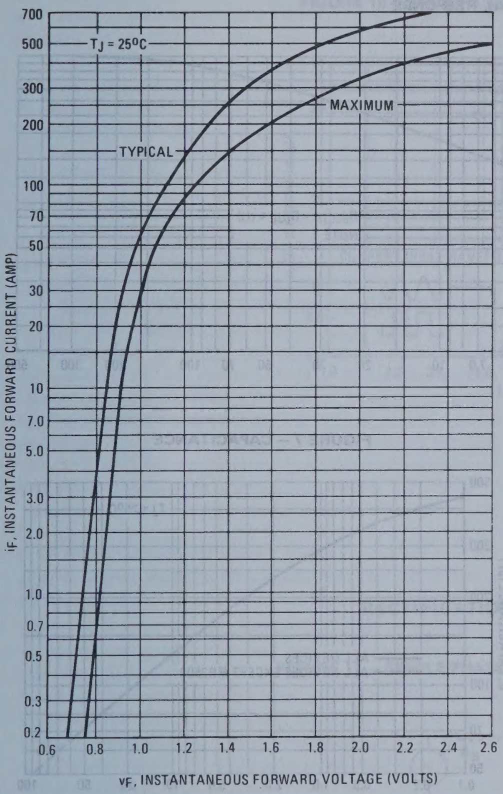


FIGURE 2 — NON-REPETITIVE SURGE CURRENT

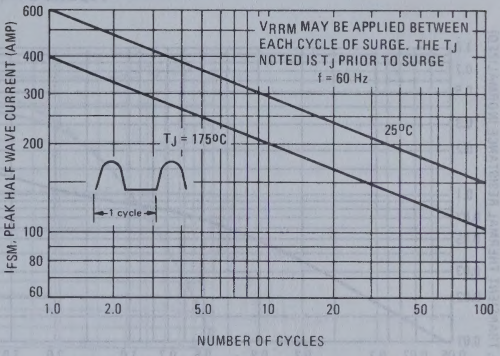


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

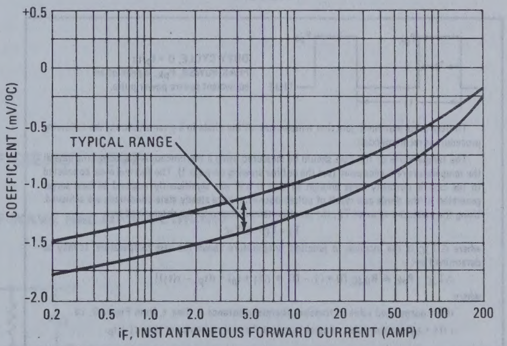


FIGURE 4 — CURRENT DERATING

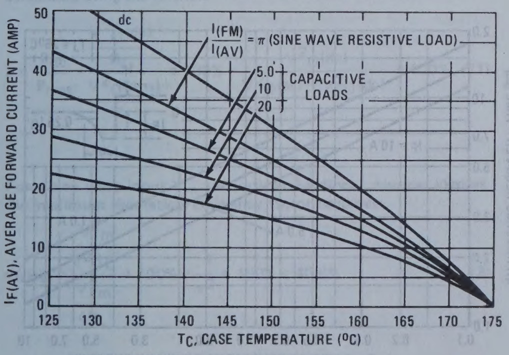


FIGURE 5 — FORWARD POWER DISSIPATION

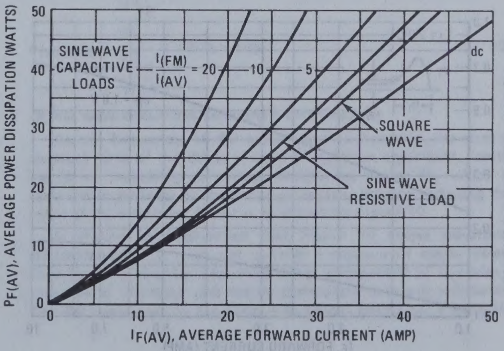
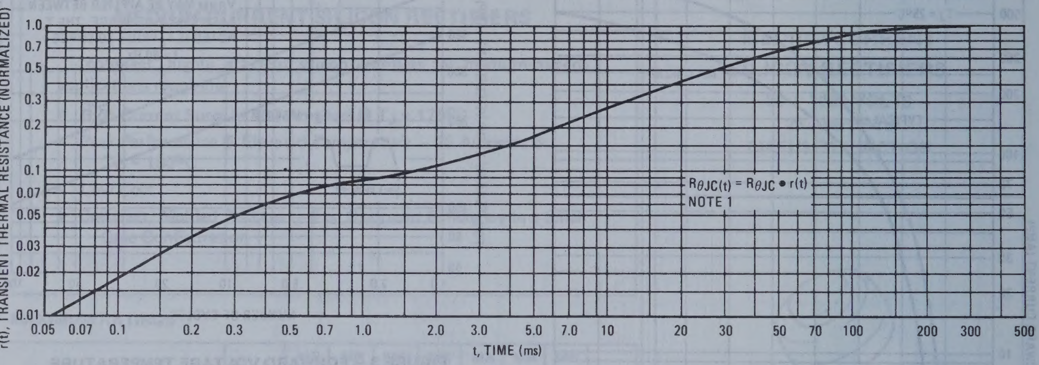
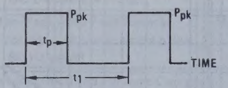


FIGURE 6 – THERMAL RESPONSE



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended.

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see the outline drawing on page 1). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \bullet R_{\theta JC} [D + (1 - D) \bullet r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.,
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 7 – CAPACITANCE

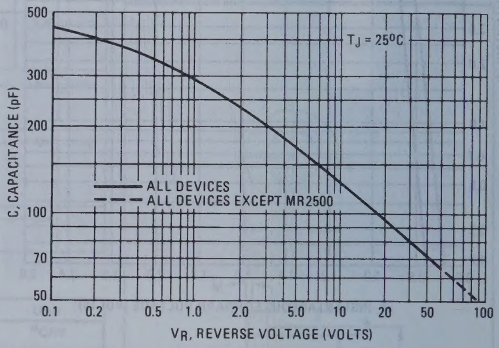


FIGURE 8 – FORWARD RECOVERY TIME

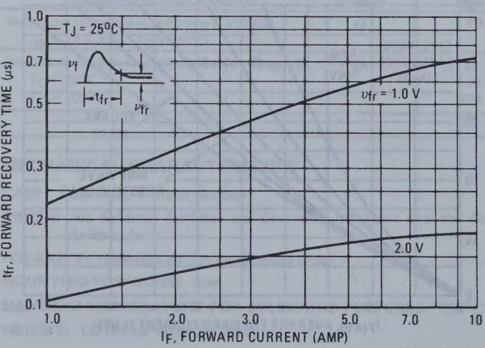


FIGURE 9 – REVERSE RECOVERY TIME

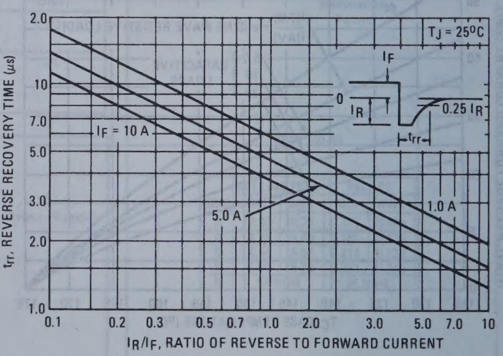
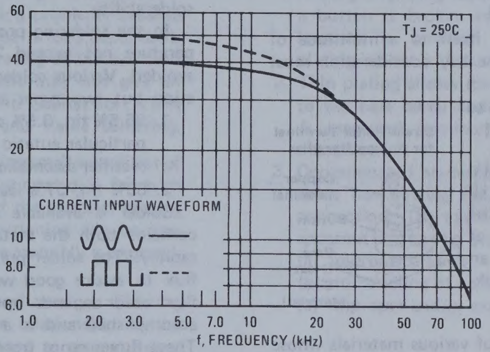
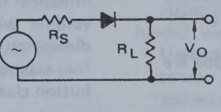


FIGURE 10 – RECTIFICATION WAVEFORM EFFICIENCY



RECTIFICATION EFFICIENCY NOTE

FIGURE 11 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 10 was calculated using the formula:

$$\sigma = \frac{P_{dc}}{P_{rms}} = \frac{\dfrac{V^2{}_{O(dc)}}{R_L}}{\dfrac{V^2{}_{O(rms)}}{R_L}} \bullet 100\% = \frac{V^2{}_{O(dc)}}{V^2{}_{O(ac)} + V^2{}_{O(dc)}} \bullet 100\% \qquad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assume lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\dfrac{V^2{}_m}{\pi^2 R_L}}{\dfrac{V^2{}_m}{4R_L}} \bullet 100\% = \frac{4}{\pi^2} \bullet 100\% = 40.6\% \qquad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\dfrac{V^2{}_m}{2R_L}}{\dfrac{V^2{}_m}{R_L}} \bullet 100\% = 50\% \qquad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 9) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 10.

It should be emphasized that Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_O with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.

ASSEMBLY AND SOLDERING INFORMATION

There are *two basic areas* of consideration for successful implementation of button rectifiers:

1. Mounting and Handling
2. Soldering

each should be carefully examined before attempting a finished assembly or mounting operation.

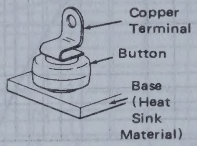
MOUNTING AND HANDLING

The button rectifier lends itself to a multitude of assembly arrangements but one key consideration must *always* be included:

One Side of the Connections to the Button Must Be Flexible!

This stress relief to the button should also be chosen for maximum contact area to afford the best heat transfer — but not at the expense of flexibility. For an annealed copper terminal a thickness of 0.015″ is suggested.

Strain Relief Terminal for Button Rectifier



The base heat sink may be of various materials whose shape and size are a function of the individual application and the heat transfer requirements.

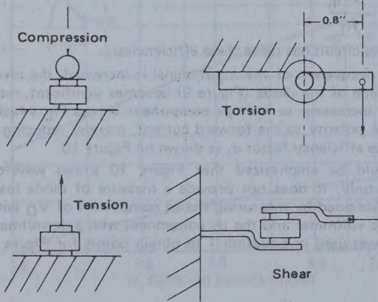
Common Materials	Advantages and Disadvantages
Steel	Low Cost; relatively low heat conductivity
Copper	High Cost; high heat conductivity
Aluminum	Medium Cost; medium heat conductivity Relatively expensive to plate and not all platers can process aluminum.

Handling of the button during assembly must be relatively gentle to minimize sharp impact shocks and avoid nicking of the plastic. Improperly designed automatic handling equipment is the worst source of unnecessary shocks. Techniques for vacuum handling and spring loading should be investigated.

The mechanical stress limits for the button diode are as follows:

Compression	32 lbs.	(29.4 kilograms)
Tension	32 lbs.	(29.4 kilograms)
Torsion	6-inch lbs.	(6900 gm-cm)
Shear	55 lbs.	(44.9 kilograms)

MECHANICAL STRESS



Exceeding these recommended maximums can result in electrical degradation of the device.

SOLDERING

The button rectifier is basically a semiconductor chip bonded between two nickel-plated copper heat sinks with an encapsulating material of thermal-setting silicone. The exposed metal areas are also tin plated to enhance solderability.

In the soldering process it is important that the temperature not exceed 250°C if device damage is to be avoided. Various solder alloys can be used for this operation but two types are recommended for best results:

1. 96.5% tin, 3.5% silver; Melting point is 221°C (this particular eutetic is used by Motorola for its button rectifier assemblies).
2. 63% tin, 37% lead; Melting point 183°C (eutetic).

Solder is available as preforms or paste. The paste contains both the metal and flux and can be dispensed rapidly. The solder preform requires the application of a flux to assure good wetting of the solder. The type of flux used depends upon the degree of cleaning to be accomplished and is a function of the metals involved. These fluxes range from a mild rosin to a strong acid; e.g., Nickel plating oxides are best removed by an acid base flux while an activated rosin flux may be sufficient for tin plated parts.

Since the button is relatively light-weight, there is a tendency for it to float when the solder becomes liquid. To prevent bad joints and misalignment it is suggested that a weighting or spring loaded fixture be employed. It is also important that severe thermal shock (either heating or cooling) be avoided as it may lead to damage of the die or encapsulant of the part.

Button holding fixtures for use during soldering may be of various materials. Stainless steel has a longer use life while black anodized aluminum is less expensive and will limit heat reflection and enhance absorption. The assembly volume will influence the choice of materials. Fixture dimension tolerances for locating the button must allow for expansion during soldering as well as allowing for button clearance.

HEATING TECHNIQUES

The following four heating methods have their advantages and disadvantages depending on volume of buttons to be soldered.

1. **Belt Furnaces** readily handle large or small volumes and are adaptable to establishment of "on-line" assembly since a variable belt speed sets the run rate. Individual furnace zone controls make excellent temperature control possible. Cost ranges from $20,000 to $30,000.
2. **Flame Soldering** involves the directing of natural gas flame jets at the base of a heatsink as the heatsink is indexed to various loading-heating-cooling-unloading positions. This is the most economical labor method of soldering large volumes. Flame soldering offers good temperature control but requires sophisticated temperature monitoring systems such as infrared. Cost ranges from $25,000 to $40,000.

ASSEMBLY AND SOLDERING INFORMATION (continued)

3. **Ovens** are good for batch soldering and are production limited. There are handling problems because of slow cooling. Response time is load dependent, being a function of the watt rating of the oven and the mass of parts. Large ovens may not give an acceptable temperature gradient. Capital cost is low compared to belt furnaces and flame soldering.
4. **Hot Plates** are good for soldering small quantities of prototype devices. Temperature control is fair with overshoot common because of the exposed heating surface. Solder flow and positioning can be corrected during soldering since the assembly is exposed. Investment cost is very low.

Regardless of the heating method used, a soldering profile giving the time-temperature relationship of the particular method must be determined to assure proper soldering. Profiling must be performed on a scheduled basis to minimize poor soldering. The time-temperature relationship will change depending on the heating method used.

SOLDER PROCESS EVALUATION

Characteristics to look for when setting up the soldering process:

I **Overtemperature** is indicated by any one or all three of the following observations.
  1. Remelting of the solder inside the button rectifier shows the temperature has exceeded 285°C and is noted by "islands" of shiny solder and solder dewetting when a unit is broken apart.
  2. Cracked die inside the button may be observed by a moving reverse oscilloscope trace when pressure is applied to the unit.
  3. Cracked plastic may be caused by thermal shock as well as overtemperature so cooling rate should also be checked.

II **Cold soldering** gives a grainy appearance and solder build-up without a smooth continuous solder fillet. The temperature must be adjusted until the proper solder fillet is obtained within the maximum temperature limits.

III **Incomplete solder fillets** result from insufficient solder or parts not making proper contact.

IV **Tilted buttons** can cause a void in the solder between the heatsink and button rectifier which will result in poor heat transfer during operation. An eight degree tilt is a suggested maximum value.

V **Plating problems** require a knowledge of plating operations for complete understanding of observed deficiencies.
  1. Peeling or plating separation is generally seen when a button is broken away for solder inspection. If heatsink or terminal base metal is present the plating is poor and must be corrected.
  2. Thin plating allows the solder to penetrate through to the base metal and can give a poor connection. A suggested minimum plating thickness is 300 microinches.
  3. Contaminated soldering surfaces may out-gas and cause non-wetting resulting in voids in the solder connection. The exact cause is not always readily apparent and can be because of:
     (a) improper plating
     (b) mishandling of parts
     (c) improper and/or excessive storage time

SOLDER PROCESS MONITORING

Continuous monitoring of the soldering process must be established to minimize potential problems. All parts used in the soldering operation should be sampled on a lot by lot basis by assembly of a controlled sample. Evaluate the control sample by break-apart tests to view the solder connections, by physical strength tests and by dimensional characteristics for part mating.

A shear test is a suggested way of testing the solder bond strength.

POST SOLDERING OPERATION CONSIDERATIONS

After soldering, the completed assembly must be unloaded, washed and inspected.

Unloading must be done carefully to avoid unnecessary stress. Assembly fixtures should be cooled to room temperature so solder profiles are not affected.

Washing is mandatory if an acid flux is used because of its ionic and corrosive nature. Wash the assemblies in agitated hot water and detergent for three to five minutes. After washing; rinse, blow off excessive water and bake 30 minutes at 150°C to remove trapped moisture.

Inspection should be both electrical and physical. Any rejects can be reworked as required.

SUMMARY

The Button Rectifier is an excellent building block for specialized applications. The prime example of its use is the output bridge of the automative alternator where millions are used each year. Although the material presented here is not all inclusive, primary considerations for use are presented. For further information, contact the nearest Motorola Sales Office or franchised distributor.

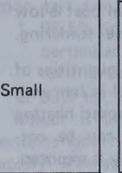
MR2500S Series (SILICON)

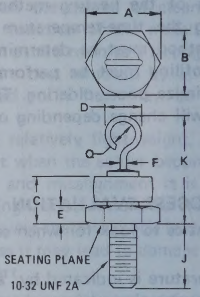
MEDIUM-CURRENT SILICON RECTIFIERS

. . . compact, highly efficient silicon rectifiers for medium-current applications requiring:

- High Current Surge – 600 Amperes
- Peak Performance at Elevated Temperature – 25 Amperes, $T_C = 150^oC$
- Low Cost
- Compact Molded Package – For Optimum Efficiency in a Small Case Configuration

MEDIUM-CURRENT
SILICON RECTIFIERS
50-1000
DIFFUSED JUNCTION





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.12	12.70	0.477	0.500
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.19	1.35	0.047	0.053
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
Q	1.52	–	0.060	–

CASE 283-01
(DO-4)

MAXIMUM RATINGS

Rating	Symbol	MR 2500 S	MR 2501 S	MR 2502 S	MR 2504 S	MR 2506 S	MR 2508 S	MR 2510 S	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz Peak)	V_{RSM}	60	120	240	480	720	960	1200	Volts
RMS Forward Current	$I_{(RMS)}$	50							Amp
Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_C = 150^oC$)	I_O	25							Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	600 (For 1 Cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175							^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.95	$^oC/W$

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage ($I_F = 79$ Amp, $T_J = 25^oC$)	v_F	1.15	Volts
Maximum Reverse Current (rated dc voltage) $T_C = 25^oC$ $T_C = 100^oC$	I_R	 100 500	μA

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded.

FINISH: All External Surfaces are Corrosion-Resistant and the Terminal Lead is Readily Solderable.

POLARITY: Cathode to Case (Reverse Polarity Units are Available and Designated by an "R" Suffix i.e., MR2500SR).

MOUNTING POSITIONS: Any.

STUD TORQUE: 15 in-lbs Maximum.

MAXIMUM TERMINAL TEMPERATURE FOR SOLDERING PURPOSES: 275°C for 10 Seconds at 3 Kg Tension.

WEIGHT: 6 Grams (Approximately).

FIGURE 1 – FORWARD VOLTAGE

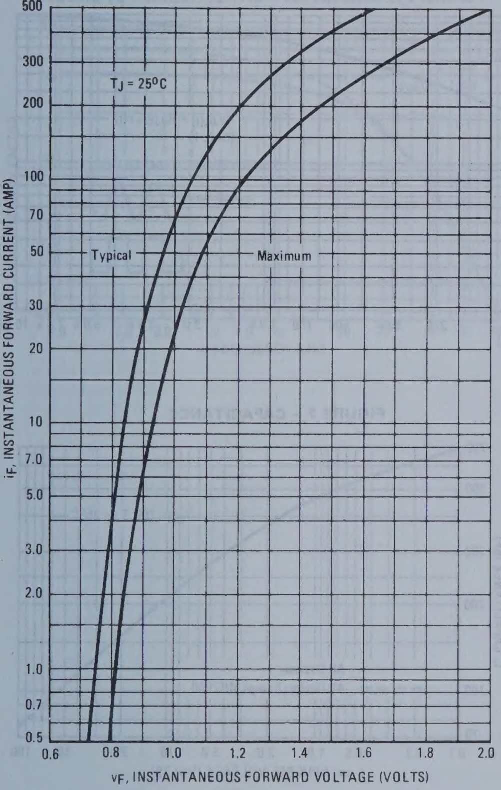


FIGURE 2 – MAXIMUM SURGE CAPABILITY

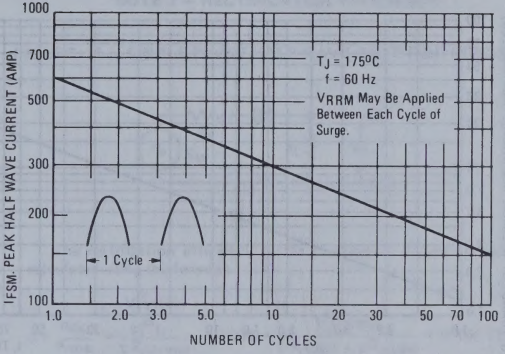


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

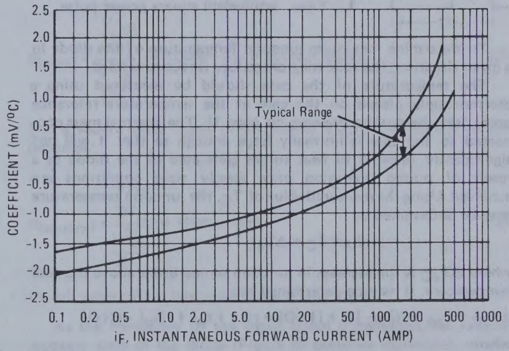


FIGURE 4 – CURRENT DERATING

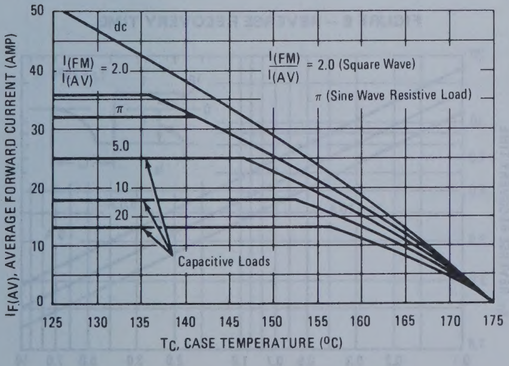


FIGURE 5 – FORWARD POWER DISSIPATION

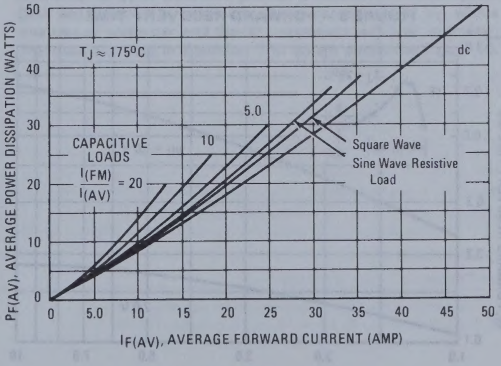
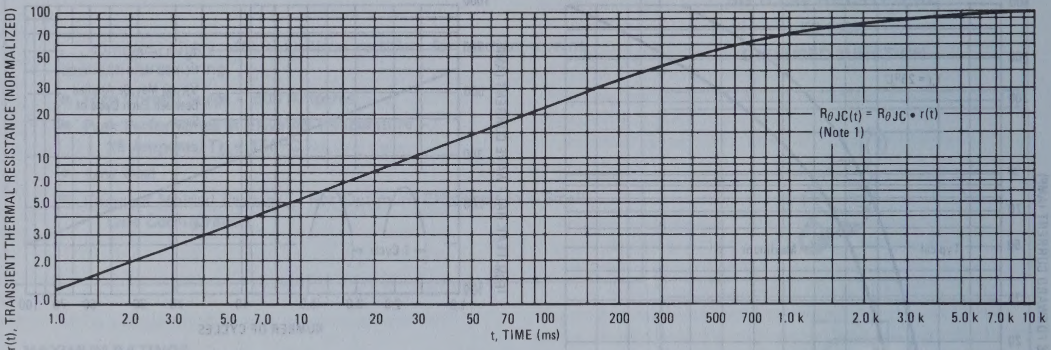
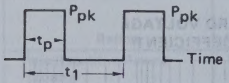


FIGURE 6 – THERMAL RESPONSE





DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended.

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see the outline drawing on page 1). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \bullet R_{\theta JC}\,[D + (1 - D) \bullet r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 7 – CAPACITANCE

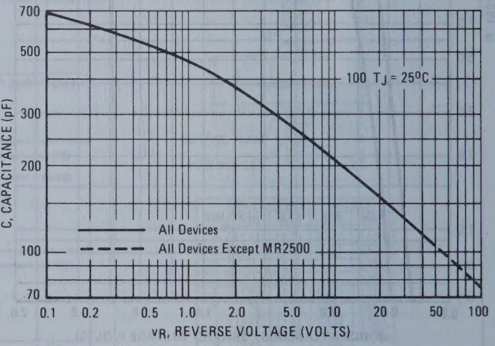


FIGURE 8 – FORWARD RECOVERY TIME

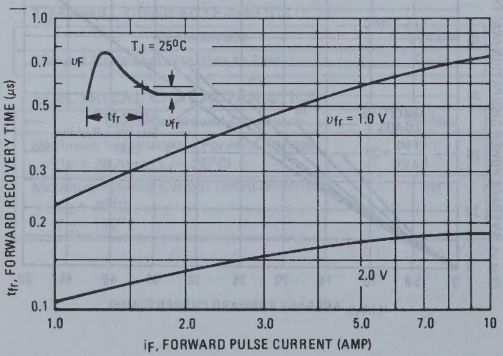


FIGURE 9 – REVERSE RECOVERY TIME

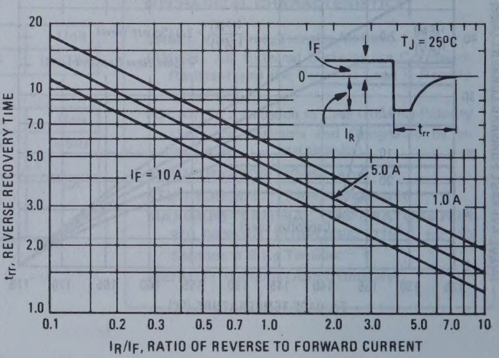
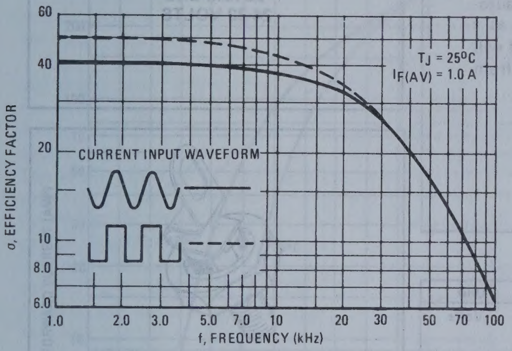
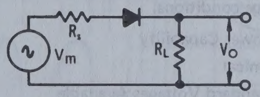


FIGURE 10 – RECTIFICATION WAVEFORM EFFICIENCY



NOTE 2 – RECTIFICATION EFFICIENCY

FIGURE 11 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 10 was calculated using the formula:

$$\sigma = \frac{P_{dc}}{P_{rms}} = \frac{\dfrac{V^2_{O(dc)}}{R_L}}{\dfrac{V^2_{O(rms)}}{R_L}} \bullet 100\% = \frac{V^2_{O(dc)}}{V^2_{O(ac)} + V^2_{O(dc)}} \bullet 100\% \qquad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\dfrac{V^2_m}{\pi^2 R_L}}{\dfrac{V^2_m}{4R_L}} \bullet 100\% = \frac{4}{\pi^2} \bullet 100\% = 40.6\% \qquad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\dfrac{V^2_m}{2R_L}}{\dfrac{V^2_m}{R_L}} \bullet 100\% = 50\% \qquad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 9) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 10.

It should be emphasized that **Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses.** Data was obtained by measuring the ac component of V_O with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.

MR2525
MR2525R

POWER RECTIFIER/POWER SURGE SUPPRESSOR

. . . designed for applications requiring a low voltage rectifier with reverse avalanche characteristics or for use as a reverse power transient suppressor. Developed to suppress transients in the automotive system, this device operates in the forward mode as a standard rectifier or reverse mode as a power zener diode and will protect expensive mobile transceivers, radios and tape decks from over-voltage conditions.

- High Power Capability
- Economical
- Non-Standard Voltages Available
- Increased Capacity by Parallel Operation

MAXIMUM RATINGS

Rating	Symbol	Limit	Unit
DC Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	23	Volts
RMS Forward Current	$I_{(RMS)}$	94	Amp
Average Rectified Forward Current (Single Phase, Resistive Load, $T_C = 150^{\circ}C$)	I_O	25	Amp
Non-Repetitive Peak Forward Surge Current (Surge Applied at Rated Load Conditions, Halfwave, Single Phase 60 Hz)	I_{FSM}	600	Amp
Repetitive Peak Reverse Surge Current (Pulse Width = 10 ms, Duty Cycle $\leqslant$ 1.0%, $T_C = 85^{\circ}C$) Exponential (See Figure 5) Square Wave (See Figure 4)	I_{RSM}	 62 40	Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.95	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Instantaneous Forward Voltage (1) ($i_F = 79$ Amp, $T_J = 25^{\circ}C$)	v_F	–	1.1	Volts
Reverse Current ($V_R = 20$ Vdc, $T_C = 25^{\circ}C$) ($V_R = 20$ Vdc, $T_C = 100^{\circ}C$)	I_R	 – –	 50 300	μAdc
Breakdown Voltage ($I_R = 100$ mAdc, $T_C = 25^{\circ}C$)	BV	24	32	Volts
Breakdown Voltage (2) ($I_R = 40$ Amp, $T_C = 85^{\circ}C$)	BV_M	–	40	Volts

MECHANICAL CHARACTERISTICS

Case: Void free, transfer molded

Finish: All external surfaces are corrosion-resistant and the terminal lead is readily solderable

Polarity: Standard polarity is cathode to case – MR2525
Reverse polarity is anode to case and is designated by an "R" suffix – MR2525R

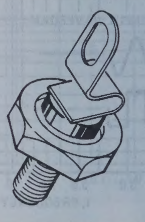
Mounting Position: Any

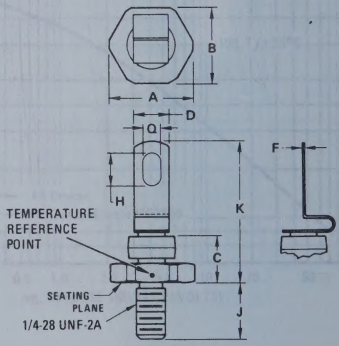
Stud Torque: 20 in-lbs maximum

(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.
(2) Pulse Test: Pulse Width $\leqslant$ 10 ms, Duty Cycle $\leqslant$ 2.0%.

AVALANCHE RECTIFIER

25 AMPERE
24-32 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.29	–	0.720	–
B	16.99	17.48	0.669	0.688
C	–	10.67	–	0.420
D	–	8.38	–	0.330
F	0.46	0.56	0.018	0.022
H	7.62	8.13	0.300	0.320
J	10.72	11.51	0.422	0.453
K	–	30.48	–	1.200
Q	4.44	4.70	0.175	0.185

CASE 296-03

FIGURE 1 – MAXIMUM FORWARD VOLTAGE

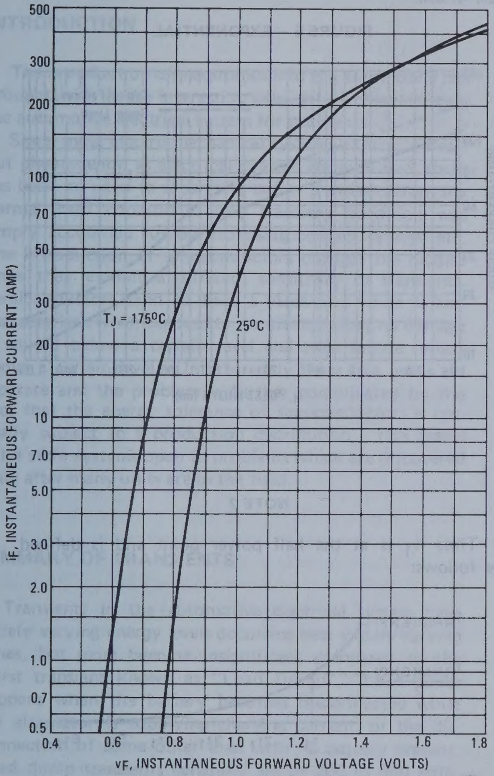
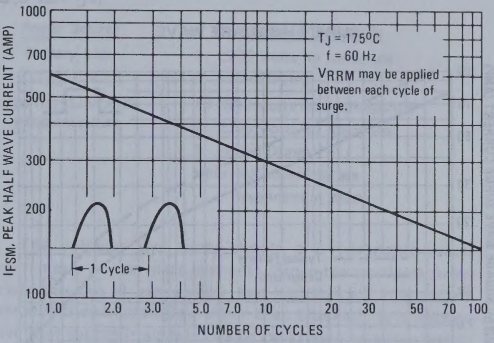
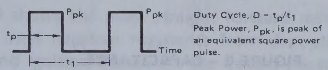


FIGURE 2 – MAXIMUM FORWARD NON-REPETITIVE SURGE CURRENT



NOTE 1


P_{pk}
P_{pk}
t_p
t_1
Time
Duty Cycle, D = t_p/t_1
Peak Power, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see the outline drawing on page 1). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by: $T_J = T_C + \Delta T_{JC}$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

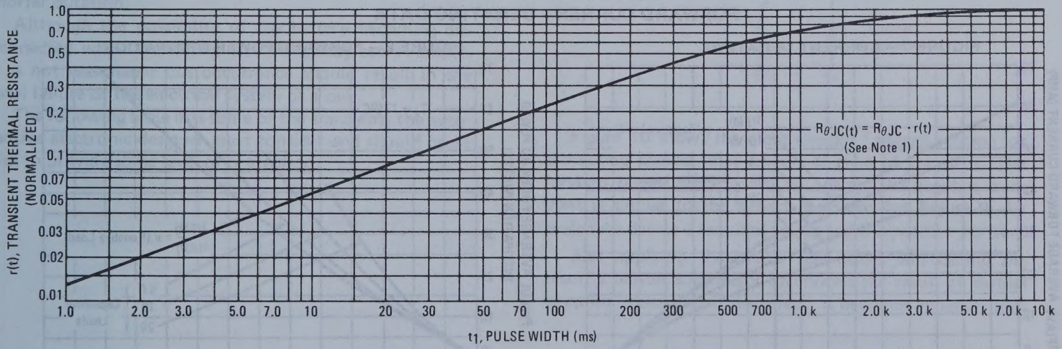
$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC}\,[D + (1-D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$

where:

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i.e.,

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 3 – THERMAL RESPONSE



REPETITIVE REVERSE SURGE CURRENT

(T_C = 85°C, Duty Cycle ≤1.0%)

FIGURE 4 – SQUARE WAVE

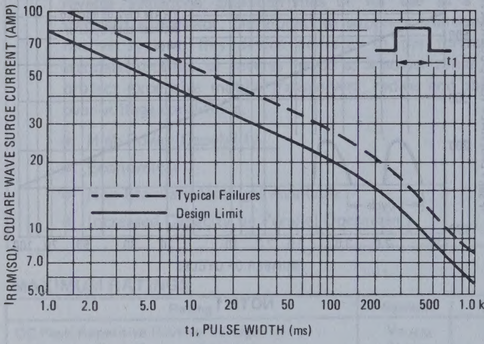


FIGURE 5 – EXPONENTIAL

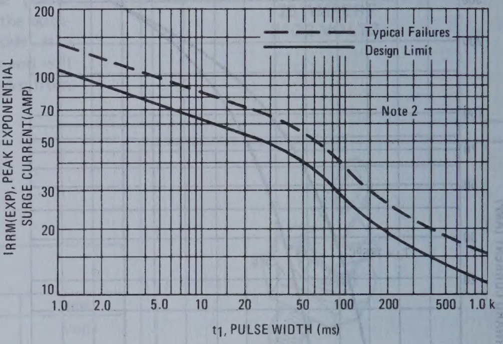
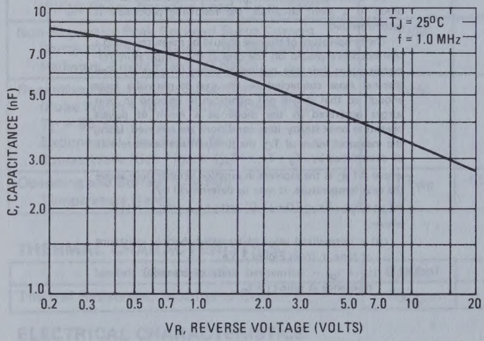
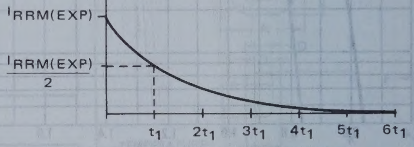


FIGURE 6 – CAPACITANCE



NOTE 2

Time t_1 is at the half power point and is defined as follows:



The time constant of the exponential curve can be found by multiplying t_1 by 1.44.

FORWARD CURRENT DERATING DATA

FIGURE 7 – CURRENT DERATING

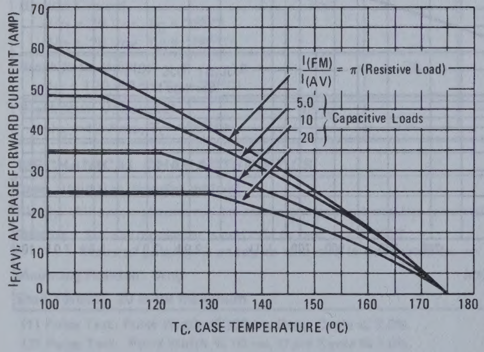
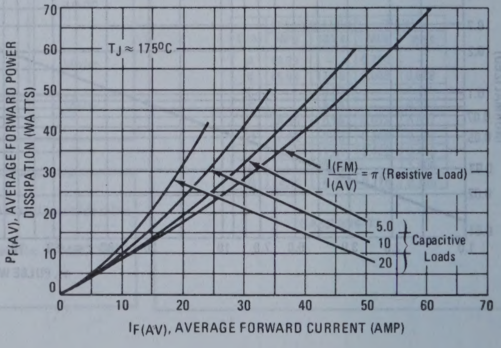


FIGURE 8 – FORWARD POWER DISSIPATION



TRANSIENTS IN THE AUTOMOTIVE ELECTRICAL SYSTEM

INTRODUCTION

The introduction of electronics into the automobile has brought with it the interesting sidelight of characterizing the automotive electrical system for transients.

Since most electro-mechanical systems exhibit a wear-out phenomenon as electrical stresses are increased, there has been no need to separately define transients from the normal load conditions. Any transient condition was simply accounted for by increasing contact ratings, etc. The introduction of semiconductors changes the picture since they exhibit a different sensitivity to transients. Semiconductors tend to have a black and white failure characteristic when exposed to transients in that no damage is caused below a certain level and total failure results above a certain level. Unfortunately these two levels are separate and the problem is further complicated by the fact that the energy tolerance of semiconductors is normally subject to a production distribution. This leaves solid state systems open to problems which are discovered only after many units are in the field.

SUMMARY OF TRANSIENTS

Transients in the automotive electrical system have widely varying energy levels occurring over widely varying times, but most become insignificant compared to the worst transient known as "Load Dump". Load dump happens when the battery becomes disconnected while the alternator is supplying charging current, or the disconnection of some other load with no battery present. Load dump transients generally are of 200 to 500 milliseconds duration, having an exponential decay from a worst case peak voltage of 80-120 volts. A clamped load dump, it should be noted, will be of considerably shorter duration.

Although the possibility of the battery becoming disconnected while the engine is running may seem remote, it is not reasonable this occurrence should result in the total failure of the electrical system of a car.

The following table lists some of the transients the automotive electronic designer must consider and should cause him to provide some level of protection.

Power Source	Available Transients
Battery Line	1. ±200 Volts for μseconds 2. +Load Dump
Ignition Line and Accessory Line	1. -300 Volts for milliseconds 2. ±200 Volts for μseconds 3. +Load Dump Note: All transients are exponential decay.

The voltages and times shown are reasonable values from many on-car measurements. Since the nonload-dump transients are of low energy, but high voltage, it is recommended they be clamped rather than blocked. It is imperative that source impedances also be known to allow proper selection of clamp devices.

STOPPING THE TRANSIENTS AT THE SOURCE

Figure 9 shows the most straight forward method of preventing large negative transients from disrupting the accessory and ignition busses. At the instant the switch is opened, the current flowing in the inductance will transfer to the diode producing about 1 volt negative on that particular buss. This condition will remain until the current in the inductance decays at a rate determined by the L/R time constant for the circuit. It can be shown that the peak currents and transient durations available in the car can easily be absorbed by a 1N4003 diode.

FIGURE 9

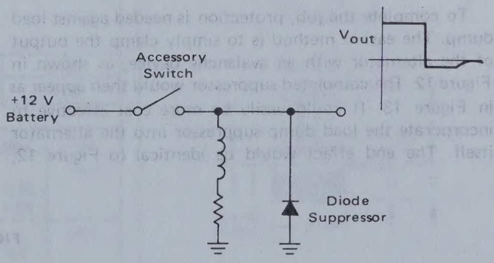
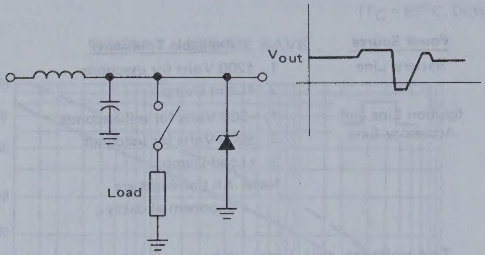


Figure 10 shows the most straight forward scheme for protecting against the series L-C type of transient. The forward biased diode action to protect the negative transient is similar to the action described for Figure 9. An avalanche device is required to clip off the positive portion.

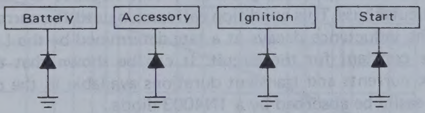
Just applying these two techniques and calling the result a master suppressor, overlooks the result of mutual coupling. Because of this effect, it becomes apparent that

FIGURE 10



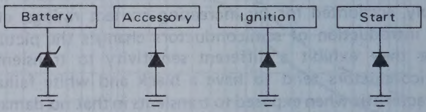
protecting against positive inductive transients at one spot is useless. Using the technique shown in Figure 10 to protect the various lines, would not be money well spent, since the same level of protection would still be required at each module anyway, due to mutual coupling. The best central suppressor for negative transients, then, is shown in Figure 11.

FIGURE 11



To complete the job, protection is needed against load dump. The easiest method is to simply clamp the output of the alternator with an avalanche device, as shown in Figure 12. The completed suppressor would then appear as in Figure 13. It could easily be more cost effective to incorporate the load dump suppressor into the alternator itself. The end effect would be identical to Figure 12, however, the implementation would require placing 3 avalanche devices in place of the present 3 diodes in the ground side of the diode bridge in the alternator.

FIGURE 13



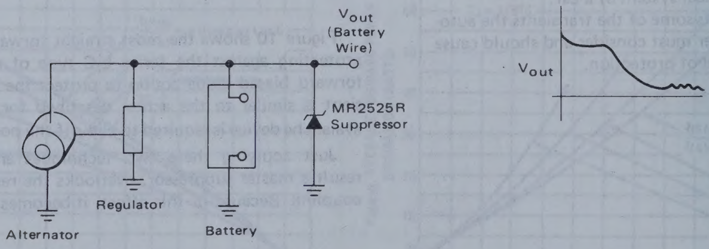
REVERSE BATTERY

Installing a battery with the terminals reversed today causes total failure of the charging system. Usually a fuse link fails, however, some cars suffer alternator failure. This condition is caused by a large current in-rush through the diode bridge which is forward biased during reverse battery condition. The master suppressor proposed in Figure 13 will suffer the same fate. While a suppressor can easily be devised, which will not drain current during −12 V condition, it is apparent that this defeats the purpose of the suppressor. In order to make this concept feasible, a circuit breaker must be inserted in series with the main battery lead.

PARALLEL OPERATION

Higher surge current capabilities can be obtained by paralleling the basic suppressor cells. Contact Motorola Semiconductor Products Division through the nearest sales office of franchised distributor for more information on number of cells required and package configurations available.

FIGURE 12



MR5005, MR5010, MR5020 (SILICON) MR5030, MR5040

INDUSTRIAL PRESSFIT SILICON POWER RECTIFIERS

. . . designed for use in all medium-current applications or for higher current industrial alternators and chassis mounted power supply rectifiers.

- 50 Amp @ $T_C = 150^oC$
- 600 Amp Surge Capability
- Reverse Polarity Available
- Rugged Construction

MAXIMUM RATINGS

Rating	Symbol	MR5005	MR5010	MR5020	MR5030	MR5040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	400	450	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 150^oC$	I_O	← 50 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 600 →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +195 →					^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	$^oC/W$

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage	V_F				Volts
(i_F = 157 Amp, $T_J = 25^oC$)		–	1.10	1.18	
(i_F = 50 Amp, $T_J = 25^oC$)		–	0.95	1.00	
Reverse Current (rated dc voltage)	I_R				mA
($T_C = 25^oC$)		–	0.05	0.2	
($T_C = 150^oC$)		–	1.0	2.0	

MECHANICAL CHARACTERISTICS

CASE: Welded hermetically sealed construction

FINISH: All external surfaces corrosion resistant, terminal readily solerable

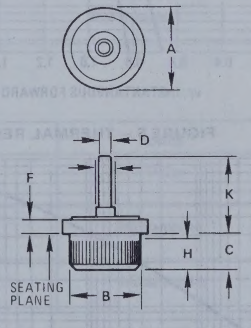
WEIGHT: 9 grams (approx.)

POLARITY: Cathode connected to case (reverse polarity available denoted by Suffix R, i.e.: MR5030R)

MOUNTING POSITION: Any

SILICON POWER RECTIFIERS

50-400 VOLTS
50 AMPERE



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.49	16.26	0.610	0.640
B	12.73	12.83	0.501	0.505
C	5.08	6.35	0.200	0.250
D	2.46	2.62	0.097	0.103
F	2.03	4.83	0.080	0.190
H	5.08	6.35	0.200	0.250
J	–	3.56	–	0.140
K	–	15.24	–	0.600

CASE 043-04

FIGURE 1 – CURRENT DERATING

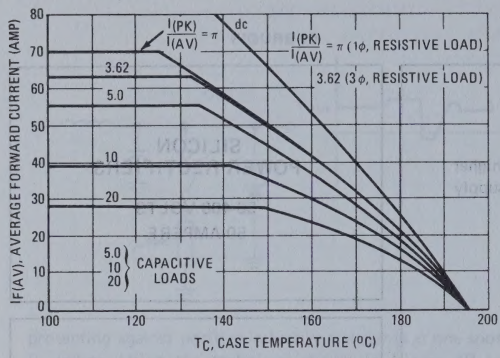


FIGURE 2 – FORWARD POWER DISSIPATION

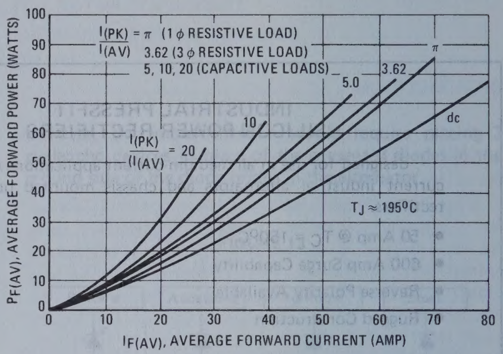


FIGURE 3 – MAXIMUM FORWARD VOLTAGE

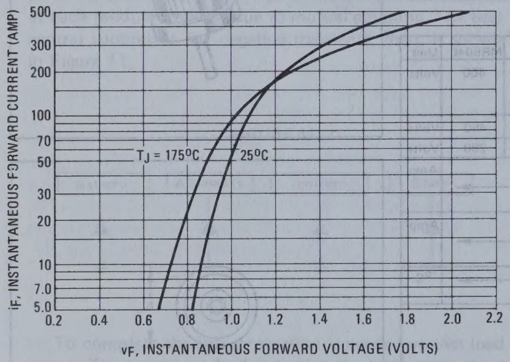


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CAPABILITY

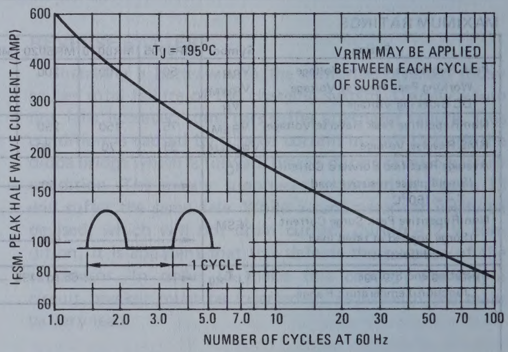
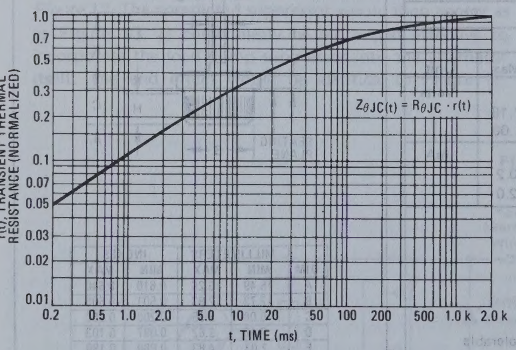
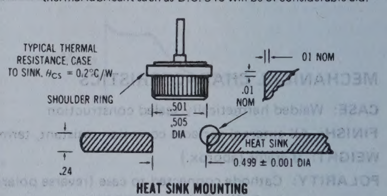


FIGURE 5 – THERMAL RESPONSE

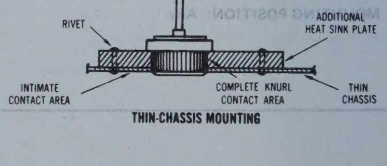


Recommended procedures for mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± 0.001 inch in diameter.
2. Break the hole edge as shown to provide a guide into the hole and prevent shearing off the knurled side of the rectifier.
3. The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.
4. To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case as shown.
5. The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a thermal lubricant such as D.C. 340 will be of considerable aid.


TYPICAL THERMAL RESISTANCE, CASE TO SINK, θCS = 0.2°C/W
SHOULDER RING
.501
.505
DIA
.01 NOM
.01
NOM
.24
HEAT SINK
0.499 ± 0.001 DIA

HEAT SINK MOUNTING


RIVET
ADDITIONAL HEAT SINK PLATE
INTIMATE CONTACT AREA
COMPLETE KNURL CONTACT AREA
THIN CHASSIS

THIN-CHASSIS MOUNTING

MRA133, MRA133B (SILICON)

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA130 series is an air-cooled, integral rectifier assembly engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	Value	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	V_{RSM}	400	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, $T_C = 150^oC$)	I_o	150	Amperes
Non-Repetitive Surge Currents at Rated Conditions	I_{FSM}	3000 for 1/2 cycle 1800 for 6 cycles	Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150^oC$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Single-Phase, Center Tap (2-1-1-C)	1 Diode Assembly Either Polarity	300 Amperes
Single-Phase Bridge (4-1-1-B)	2 Diode Assemblies, One Each Polarity	300 Amperes

Maximum Operating and Storage Temperature: -65^oC to $+150^oC$ (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	20	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	1.5	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA133R. (See Figure 2.)

MOUNTING POSITION: Diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA133B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

FIGURE 1 – MAXIMUM CIRCUIT RATINGS

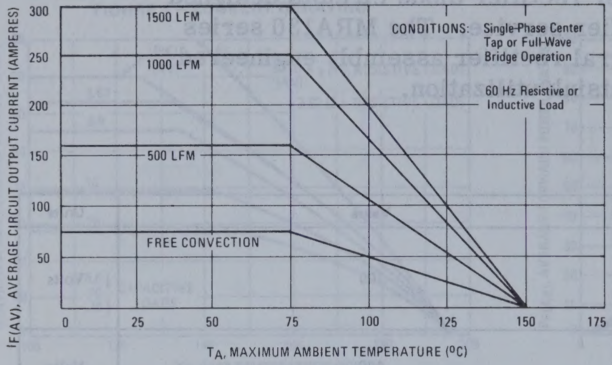


FIGURE 2 – MRA133 ("C" CIRCUIT)

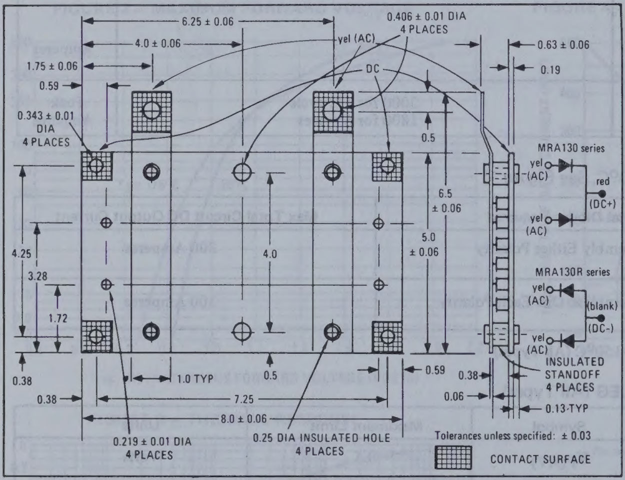
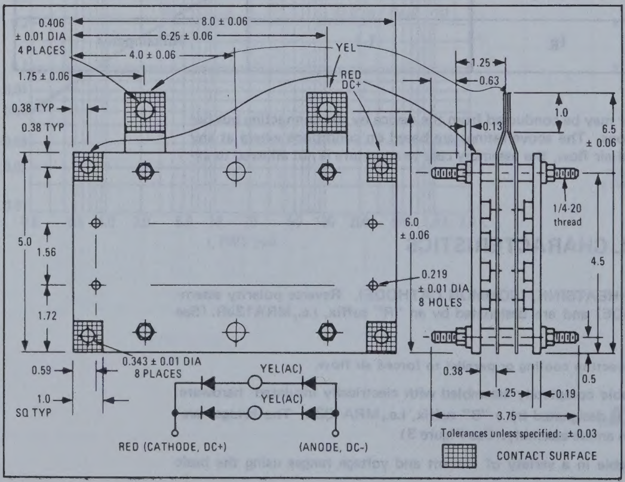
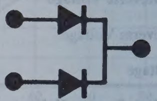
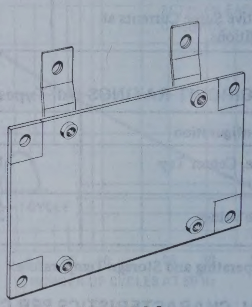

6.25 ± 0.06
4.0 ± 0.06
1.75 ± 0.06
0.59
0.343 ± 0.01 DIA 4 PLACES
0.406 ± 0.01 DIA 4 PLACES
yel (AC)
DC
0.63 ± 0.06
0.19
0.5
6.5 ± 0.06
5.0 ± 0.06
4.0
4.25
3.28
1.72
0.38
1.0 TYP
0.5
0.59
0.38
0.06
0.13 TYP
7.25
8.0 ± 0.06
0.219 ± 0.01 DIA 4 PLACES
0.25 DIA INSULATED HOLE 4 PLACES
MRA130 series
yel
(AC)
red
(DC+)
MRA130R series
(blank)
(DC-)
INSULATED STANDOFF 4 PLACES
Tolerances unless specified: ± 0.03
CONTACT SURFACE

FIGURE 3 – MRA133B (BRIDGE CIRCUIT)

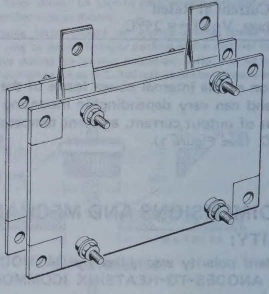

0.406 ± 0.01 DIA 4 PLACES
8.0 ± 0.06
6.25 ± 0.06
4.0 ± 0.06
1.75 ± 0.06
0.38 TYP
0.38 TYP
YEL
RED DC+
1.25
0.63
1.0
0.13
6.5 ± 0.06
1/4-20 thread
6.0 ± 0.06
5.0
1.56
1.72
4.5
0.219 ± 0.01 DIA 8 HOLES
0.343 ± 0.01 DIA 8 PLACES
0.59
1.0 SQ TYP
YEL(AC)
YEL(AC)
RED (CATHODE, DC+)
(ANODE, DC-)
0.38
1.25
0.19
0.5
3.75
Tolerances unless specified: ± 0.03
CONTACT SURFACE



"C" CIRCUIT FOR SINGLE-PHASE OPERATION



CASE 154A



CASE 155A

MRA163, MRA163B (SILICON)

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA163 is an air-cooled, integral rectifier assembly engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	Value					Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	300	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	V_{RSM}	75	150	400	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, $T_C = 150^oC$)	I_o	300					Amperes
Non-Repetitive Surge Currents at Rated Conditions	I_{FSM}	6000 for 1/2 cycle 3600 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150^oC$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Single-Phase, Center Tap (2-1-1-C)	1 Diode Assembly Either Polarity	600 Amperes
Single-Phase Bridge (4-1-1-B)	2 Diode Assemblies One Each Polarity	600 Amperes

Maximum Operating and Storage Temperature: -65^oC to $+150^oC$ (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	40	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	3.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150^oC. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e.,MRA163R. (See Figure 2.)

MOUNTING POSITION: Cooling fins and diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e.,MRA163B. The bridges are composed of one common cathode and one common anode assembly.(See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

FIGURE 1 – MAXIMUM CIRCUIT RATINGS

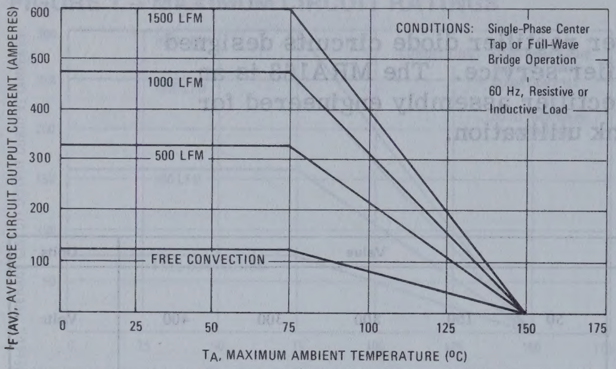


FIGURE 2 – MRA163 ("C" CIRCUIT)

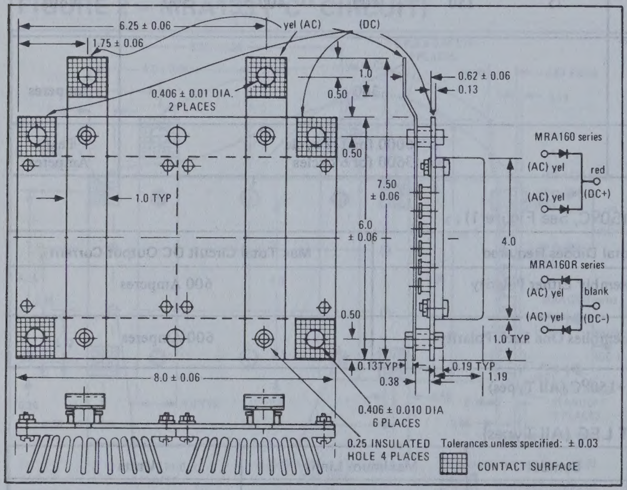
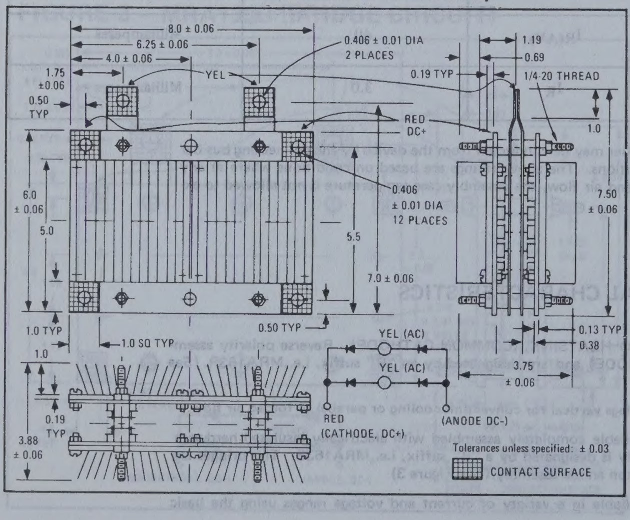
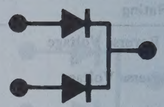
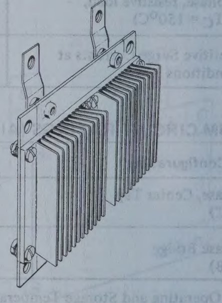

6.25 ± 0.06
1.75 ± 0.06
yel (AC)
(DC)
0.406 ± 0.01 DIA. 2 PLACES
1.0
0.50
0.62 ± 0.06
0.13
0.50
7.50 ± 0.06
1.0 TYP
6.0 ± 0.06
4.0
0.50
1.0 TYP
MRA160 series
(AC) yel
red
(DC+)
(AC) yel
MRA160R series
(AC) yel
blank
(AC) yel
(DC-)
0.13 TYP
0.38
0.19 TYP
1.19
8.0 ± 0.06
0.406 ± 0.010 DIA 6 PLACES
0.25 INSULATED HOLE 4 PLACES
Tolerances unless specified: ± 0.03
CONTACT SURFACE

FIGURE 3 – MRA163B (BRIDGE CIRCUIT)

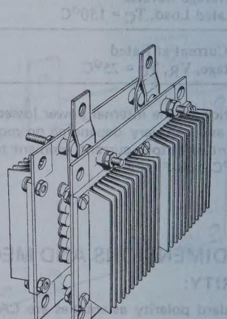

8.0 ± 0.06
6.25 ± 0.06
4.0 ± 0.06
1.75 ± 0.06
0.50 TYP
YEL
0.406 ± 0.01 DIA 2 PLACES
1.19
0.69
0.19 TYP
1/4-20 THREAD
RED DC+
1.0
0.406 ± 0.01 DIA 12 PLACES
6.0 ± 0.06
5.0
5.5
7.50 ± 0.06
7.0 ± 0.06
1.0 TYP
1.0 SQ TYP
0.50 TYP
YEL (AC)
YEL (AC)
0.13 TYP
0.38
3.75 ± 0.06
1.0
0.19 TYP
3.88 ± 0.06
RED (CATHODE, DC+)
(ANODE DC-)
Tolerances unless specified: ± 0.03
CONTACT SURFACE



"C" CIRCUIT FOR SINGLE-PHASE OPERATION



CASE 156A



CASE 157A

MRA333, MRA333B (SILICON)

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA333 is an air-cooled, integral rectifier assembly engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	Value	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	V_{RSM}	400	Volts
Continuous Average Rectified Forward Current (three-phase, resistive load, 60 Hz, $T_C = 150^\circ C$)	$I_{F(AV)}$	100	Amperes
Non-Repetitive Surge Currents at Rated Conditions	I_{FSM}	2000 for 1/2 cycle 1200 for 6 cycles	Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leqslant 150^\circ C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	1 Diode Assembly, Either Polarity	300 Amperes
Three-Phase Full-Wave (6-1-1-B)	2 Diode Assemblies, One Each Polarity	300 Amperes
Six-Phase Star (6-1-1-S)	2 Diode Assemblies Same Polarity	400 Amperes
Six-Phase with Interphase, 3Φ Double WYE (6-1-1-Y)	2 Diode Assemblies Same Polarity	600 Amperes

Maximum Operating and Storage Temperature: $-65^\circ C$ to $+150^\circ C$ (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^\circ C$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^\circ C$	$I_{R(AV)}$	15	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^\circ C$	I_R	1.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA333R. (See Figure 2.)

MOUNTING POSITION: Diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA333B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

FIGURE 1 – MAXIMUM CIRCUIT RATINGS

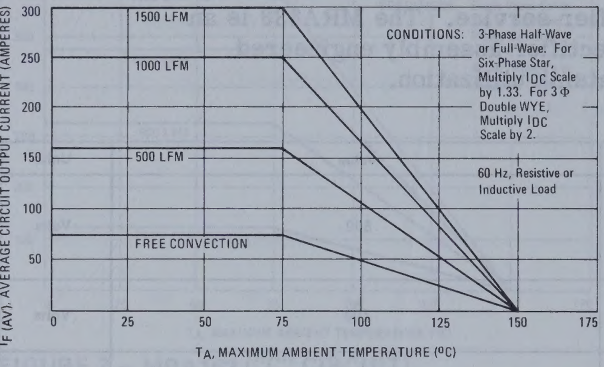
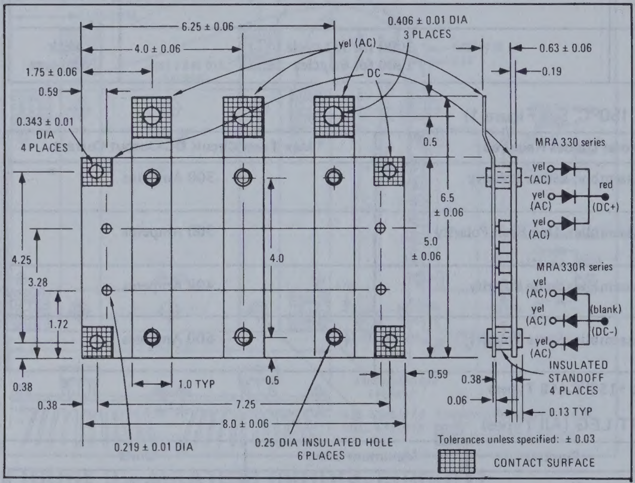
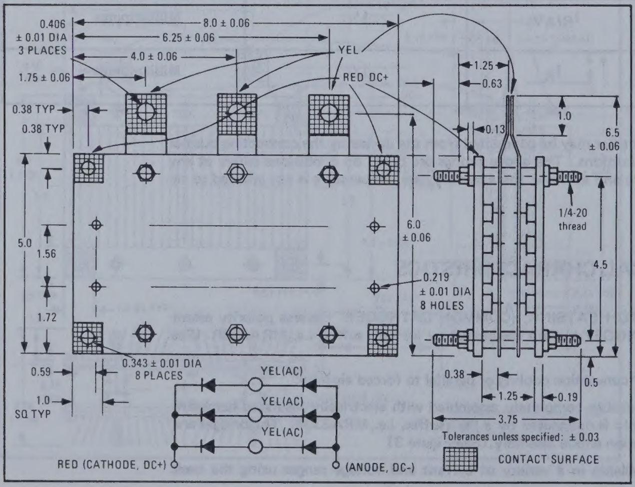


FIGURE 2 – MRA333 ("Y" CIRCUIT)

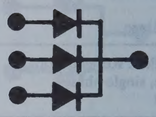


6.25 ± 0.06
4.0 ± 0.06
1.75 ± 0.06
0.59
0.343 ± 0.01 DIA 4 PLACES
0.406 ± 0.01 DIA 3 PLACES
yel (AC)
DC
0.63 ± 0.06
0.19
0.5
6.5 ± 0.06
5.0 ± 0.06
4.0
4.25
3.28
1.72
0.38
0.38
1.0 TYP
0.5
7.25
8.0 ± 0.06
0.219 ± 0.01 DIA
0.25 DIA INSULATED HOLE 6 PLACES
0.59
0.38
0.06
0.13 TYP
MRA 330 series
yel (AC)
red (DC+)
MRA330R series
(blank) (DC-)
INSULATED STANDOFF 4 PLACES
Tolerances unless specified: ± 0.03
CONTACT SURFACE

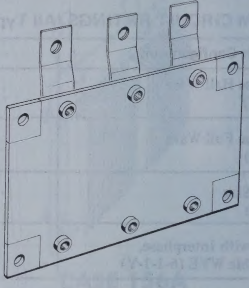
FIGURE 3 – MRA333B (BRIDGE CIRCUIT)



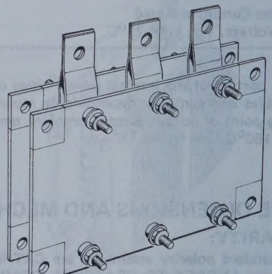
0.406 ± 0.01 DIA 3 PLACES
8.0 ± 0.06
6.25 ± 0.06
4.0 ± 0.06
1.75 ± 0.06
0.38 TYP
0.38 TYP
YEL
RED DC+
1.25
0.63
0.13
1.0
6.5 ± 0.06
6.0 ± 0.06
1/4-20 thread
4.5
5.0
1.56
1.72
0.219 ± 0.01 DIA 8 HOLES
0.59
1.0 SQ TYP
0.343 ± 0.01 DIA 8 PLACES
YEL(AC)
YEL(AC)
YEL(AC)
RED (CATHODE, DC+)
(ANODE, DC-)
0.38
1.25
0.19
0.5
3.75
Tolerances unless specified: ± 0.03
CONTACT SURFACE



"Y" CIRCUIT
FOR POLYPHASE OPERATION



CASE 154



CASE 155

MRA363, MRA363B (SILICON)

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA363 is an air-cooled, integral rectifier assembly engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	Value	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	300	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	V_{RSM}	400	Volts
Continuous Average Rectified Forward Current (three-phase, resistive load, 60 Hz, $T_C = 150^oC$)	$I_{F(AV)}$	220	Amperes
Non-Repetitive Surge Currents at Rated Conditions	I_{FSM}	5000 for 1/2 cycle 3000 for 6 cycles	Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leqslant 150^oC$, See Figure 1).

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	1 Diode Assembly Either Polarity	650 Amperes
Three-Phase Full-Wave (6-1-1-B)	2 Diode Assemblies, One Each Polarity	650 Amperes
Six-Phase Star (6-1-1-S)	2 Diode Assemblies Same Polarity	870 Amperes
Six-Phase with Interphase, 3ΦDouble WYE (6-1-1-Y)	2 Diode Assemblies Same Polarity	1300 Amperes

Maximum Operating and Storage Temperature: -65^oC to $+150^oC$ (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	40	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	3.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

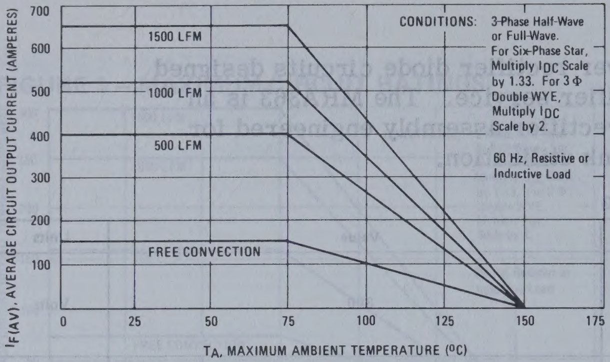
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA363R. (See Figure 2)

MOUNTING POSITION: Cooling fins and diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA363B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

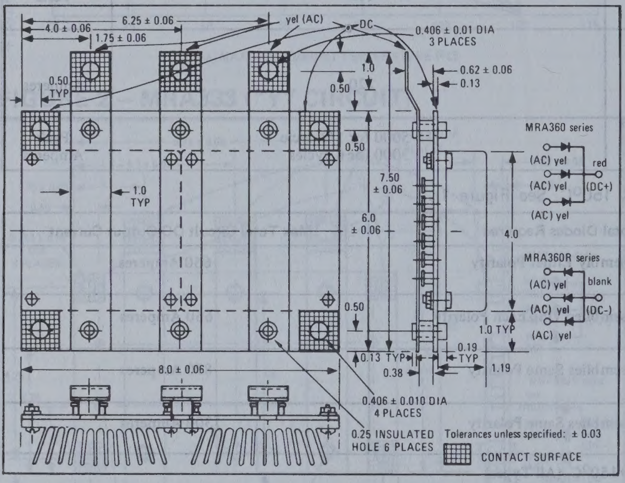
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

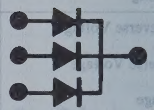


CONDITIONS: 3-Phase Half-Wave or Full-Wave. For Six-Phase Star, Multiply I_{DC} Scale by 1.33. For 3 Φ Double WYE, Multiply I_{DC} Scale by 2.

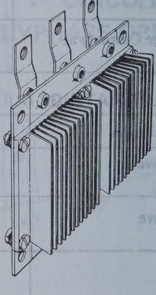
60 Hz, Resistive or Inductive Load

FIGURE 2 – MRA363 ("Y" CIRCUIT)


6.25 ± 0.06
4.0 ± 0.06
1.75 ± 0.06
yel (AC)
DC
0.406 ± 0.01 DIA
3 PLACES
0.50
TYP
1.0
0.50
0.62 ± 0.06
0.13
0.50
1.0
TYP
7.50
± 0.06
6.0
± 0.06
4.0
0.50
1.0 TYP
0.19
TYP
0.13 TYP
0.38
1.19
MRA360 series
(AC) yel
red
(AC) yel
(DC+)
(AC) yel
MRA360R series
(AC) yel
blank
(AC) yel
(DC-)
(AC) yel
8.0 ± 0.06
0.406 ± 0.010 DIA
4 PLACES
0.25 INSULATED
HOLE 6 PLACES
Tolerances unless specified: ± 0.03
CONTACT SURFACE

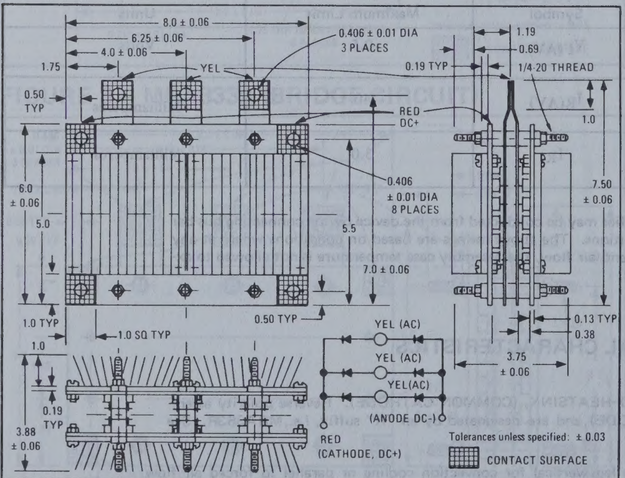


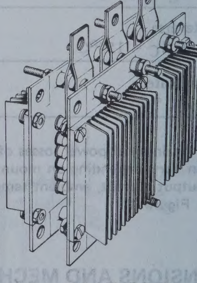
"Y" CIRCUIT FOR POLYPHASE OPERATION



CASE 156

FIGURE 3 – MRA363B (BRIDGE CIRCUIT)


8.0 ± 0.06
6.25 ± 0.06
4.0 ± 0.06
1.75
YEL
0.406 ± 0.01 DIA
3 PLACES
0.19 TYP
1.19
0.69
1/4-20 THREAD
0.50
TYP
RED
DC+
1.0
6.0
± 0.06
5.0
5.5
0.406
± 0.01 DIA
8 PLACES
7.50
± 0.06
7.0 ± 0.06
1.0 TYP
0.50 TYP
1.0 SQ TYP
1.0
0.13 TYP
0.38
YEL (AC)
YEL (AC)
YEL(AC)
3.75
± 0.06
0.19
TYP
(ANODE DC-)
3.88
± 0.06
RED
(CATHODE, DC+)
Tolerances unless specified: ± 0.03
CONTACT SURFACE



CASE 157

MRD14B (SILICON)

For Specifications, See 2N5777 Data, Volume II.

MRD150 (SILICON)

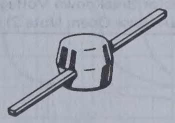
PLASTIC NPN SILICON PHOTO TRANSISTORS

. . . designed for application in punched card and tape readers, pattern and character recognition equipment, shaft encoders, industrial inspection processing and control, counters, sorters, switching and logic circuits, or any design requiring radiation sensitivity, stable characteristics and high-density mounting.

- Economical Plastic Package
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Small Size for High-Density Mounting
- High Light Current Sensitivity (0.20 mA) for Design Flexibility
- Annular◆ Passivated Structure for Stability and Reliability

40 VOLT
MICRO-T
NPN SILICON
PHOTO TRANSISTOR

50 MILLIWATTS

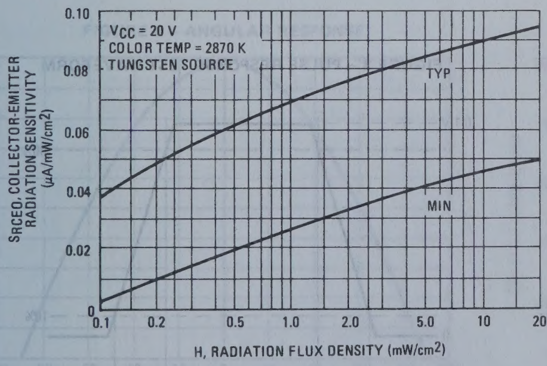


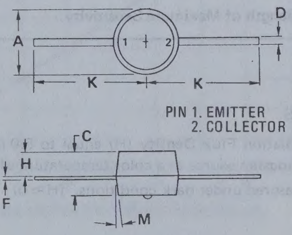
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Volts
Emitter-Collector Voltage	V_{ECO}	6.0	Volts
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	50 0.67	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J(1), T_{stg}	-40 to +100	^oC

(1) Heat Sink should be applied to leads during soldering to prevent Case Temperature from exceeding 85°C.

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY





PIN 1. EMITTER
2. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
C	1.22	1.47	0.048	0.058
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
K	4.06	–	0.160	–
M	3°	7°	3°	7°

CASE 173

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector Dark Current (V_{CC} = 20 V; Base Open) (Note 2) T_A = 25°C T_A = 85°C	–	I_{CEO}	 –	– 5.0	0.10 –	μA
Collector-Emitter Breakdown Voltage (I_C = 100 μA; Base Open; Note 2)	–	BV_{CEO}	40	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA; Base Open; Note 2)	–	BV_{ECO}	6.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector Light Current (V_{CC} = 20 V; R_L = 100 ohms; Base Open) (Note 1)	1	I_L	0.20	0.45	–	mA
Photo Current Rise Time (Note 3)	2 and 3	t_r	–	–	2.5	μs
Photo Current Fall Time (Note 3)	2 and 3	t_f	–	–	4.0	μs
Wavelength of Maximum Sensitivity	9	$\lambda_{s(typ)}$	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. For unsaturated response time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ = 0.9 μm) with a pulse width equal to or greater than 10 microseconds (see Figure 2 and Figure 3).

FIGURE 2 – PULSE RESPONSE TEST CIRCUIT

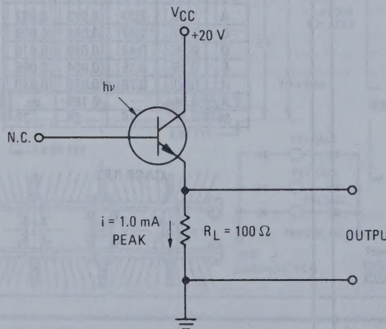
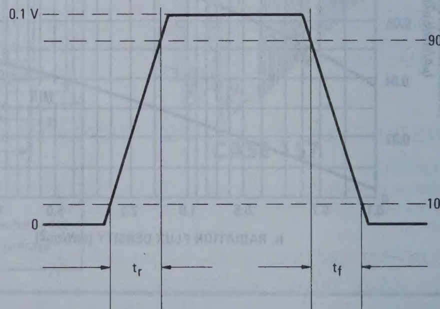


FIGURE 3 – PULSE RESPONSE TEST WAVEFORM



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 4 — COLLECTOR-EMITTER CHARACTERISTICS

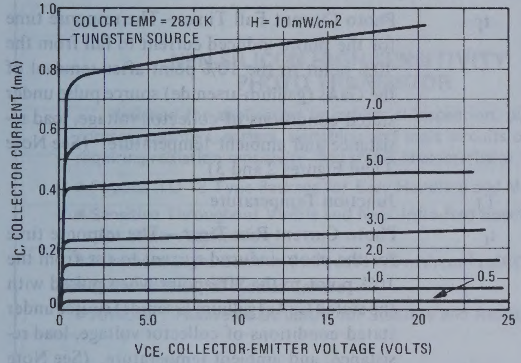


FIGURE 5 — COLLECTOR SATURATION CHARACTERISTICS

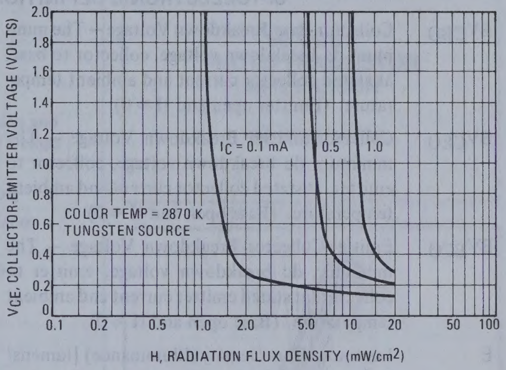


FIGURE 6 — DARK CURRENT versus TEMPERATURE

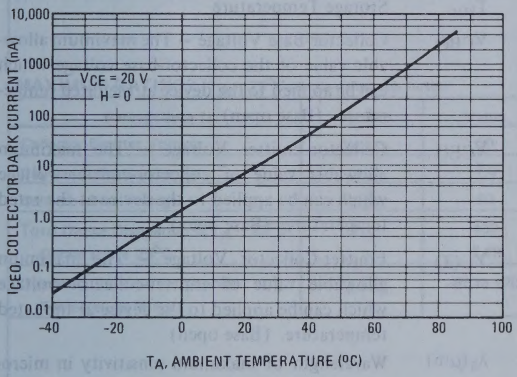


FIGURE 7 — DARK CURRENT versus VOLTAGE

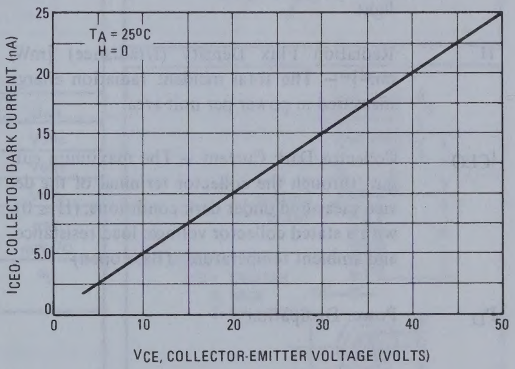


FIGURE 8 — ANGULAR RESPONSE

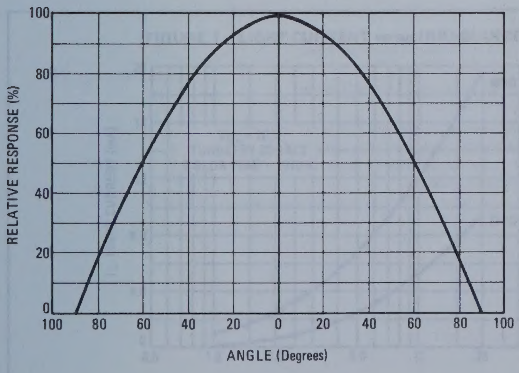
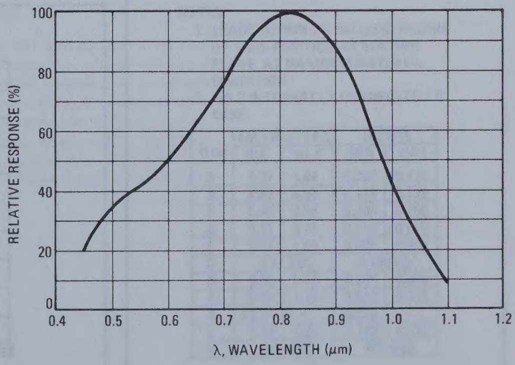


FIGURE 9 — CONSTANT ENERGY SPECTRAL RESPONSE



OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CBO}	Collector-Base Breakdown Voltage — The minimum dc breakdown voltage, collector to base, at stated collector current and ambient temperature. (Emitter open and $H \approx 0$)
BV_{CEO}	Collector-Emitter Breakdown Voltage — The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and $H \approx 0$)
BV_{ECO}	Emitter-Collector Breakdown Voltage — The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and $H \approx 0$)
E	Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] — The radiation flux density of wavelength within the band of visible light.
H	Radiation Flux Density (Irradiance) [mW/cm^2] — The total incident radiation energy measured in power per unit area.
I_{CEO}	Collector Dark Current — The maximum current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)
P_D	Power Dissipation
T_A	Ambient Temperature
t_f	Photo Current Fall Time — The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 3 and Figures 2 and 3)
T_J	Junction Temperature
t_r	Photo Current Rise Time — The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 3 and Figures 2 and 3)
T_{stg}	Storage Temperature
V_{CBO}	Collector-Base Voltage — The maximum allowable value of the collector-base voltage which can be applied to the device at the rated temperature. (Base open)
V_{CEO}	Collector-Emitter Voltage — The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)
V_{ECO}	Emitter-Collector Voltage — The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)
$\lambda_s (\mu m)$	Wavelength of maximum sensitivity in micrometers.

MRD300 (SILICON)
MRD310

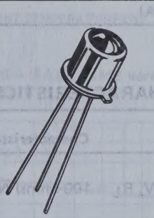
NPN SILICON HIGH SENSITIVITY PHOTO TRANSISTOR

. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wider Application
- Minimum Light Current 4 mA at H = 5 mV/cm^2 (MRD 300)
- External Base for Added Control
- Annular Passivated Structure for Stability and Reliability

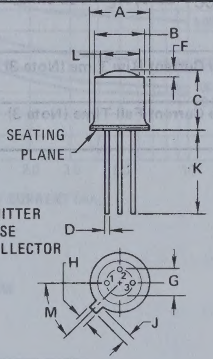
50 VOLT
PHOTO TRANSISTOR
NPN SILICON

400 MILLIWATTS



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Collector-Base Voltage	V_{CBO}	80	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	°C



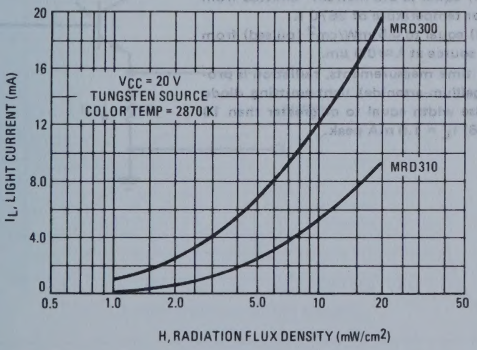
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NOTES:
1. LEADS WITHIN .13 mm (.005) RADIUS OF TRUE POSITION AT SEATING PLANE, AT MAXIMUM MATERIAL CONDITION.
2. PIN 3 INTERNALLY CONNECTED TO CASE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	5.08	6.35	0.200	0.250
D	0.41	0.48	0.016	0.019
F	0.51	1.02	0.020	0.040
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
L	3.35	4.01	0.132	0.158
M	45° BSC		45° BSC	

CASE 82-01

FIGURE 1 – LIGHT CURRENT versus IRRADIANCE



STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, H≈0) T_A = 25°C T_A = 100°C	I_{CEO}	– –	– 4.0	25 –	na μA
Collector-Base Breakdown Voltage (I_C = 100 μA)	BV_{CBO}	80	–	–	Volts
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	BV_{CEO}	50	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA)	BV_{ECO}	7.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Device Type	Symbol	Min	Typ	Max	Unit
Light Current (V_{CC} = 20 V, R_L = 100 ohms) Note 1	MRD300 MRD310	I_L	4.0 1.0	7.5 2.5	– –	mA
Light Current (V_{CC} = 20 V, R_L = 100 ohms) Note 2	MRD300 MRD310	I_L	– –	2.5 0.8	– –	mA
Photo Current Rise Time (Note 3) (R_L = 100 ohms I_L = 1.0 mA peak)		tr	–	–	2.5	μs
Photo Current Fall Time (Note 3) (R_L = 100 ohms I_L = 1.0 mA peak)		t_f	–	–	4.0	μs

NOTES:

1. Radiation flux density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Radiation flux density (H) equal to 0.5 mW/cm^2 (pulsed) from a GaAs (gallium-arsenide) source at λ≈0.9 μm.
3. For unsaturated response time measurements, radiation is provided by pulsed GaAs (gallium-arsenide) light-emitting diode (λ ≈ 0.9 μm) with a pulse width equal to or greater than 10 microseconds (see Figure 6) I_L = 1.0 mA peak.

TYPICAL ELECTRICAL CHARACTERISTICS

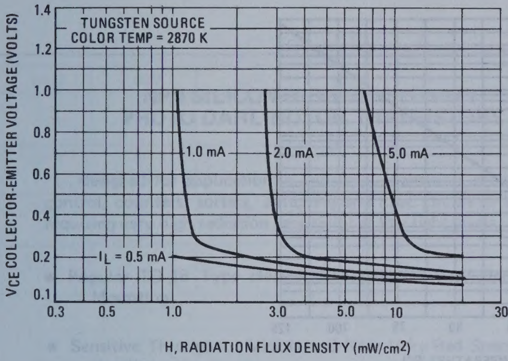


FIGURE 2 – COLLECTOR-EMITTER SATURATION CHARACTERISTIC

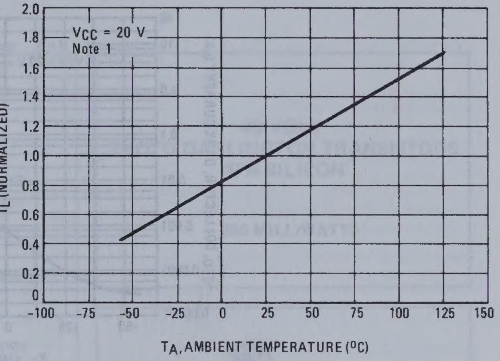


FIGURE 3 – NORMALIZED LIGHT CURRENT versus TEMPERATURE

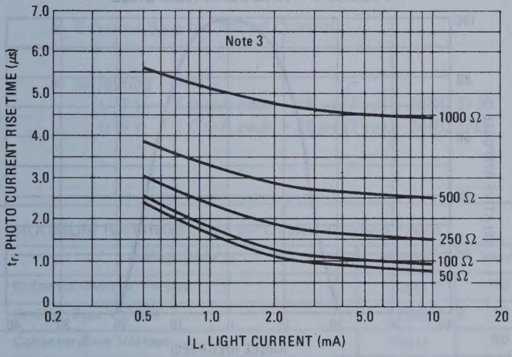


FIGURE 4 – RISE TIME versus LIGHT CURRENT

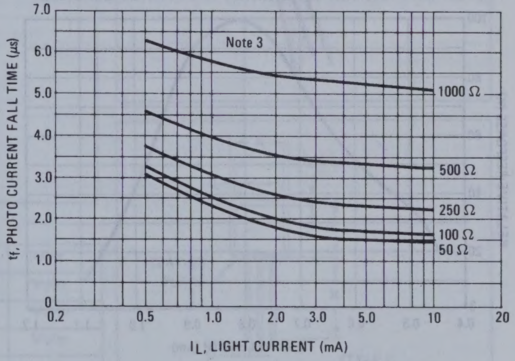


FIGURE 5 – FALL TIME versus LIGHT CURRENT

FIGURE 6 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM

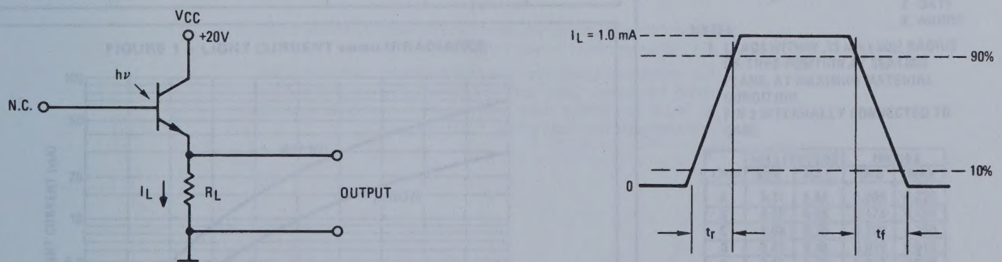

V_CC
+20V
hν
N.C.
I_L
R_L
OUTPUT
I_L = 1.0 mA
90%
10%
0
t_r
t_f

FIGURE 7 — DARK CURRENT versus TEMPERATURE

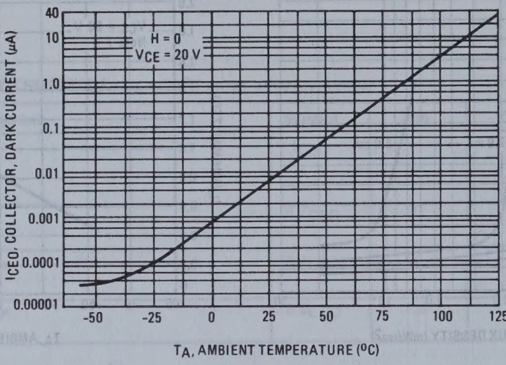


FIGURE 8 — CONSTANT ENERGY SPECTRAL RESPONSE

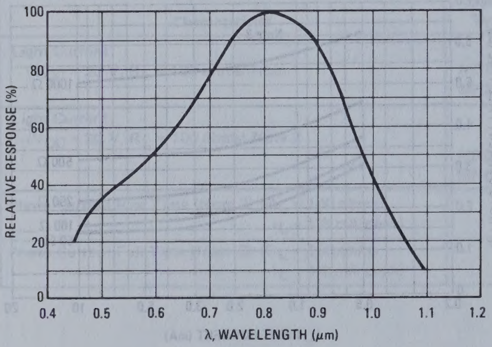
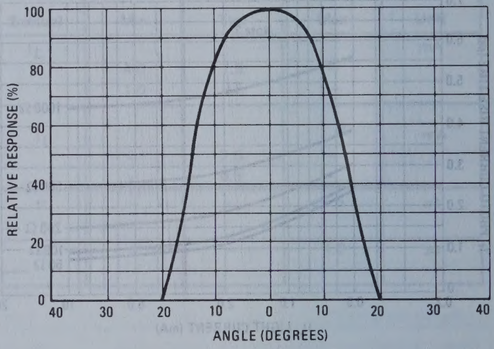


FIGURE 9 — ANGULAR RESPONSE



MRD360 (SILICON)

MRD370

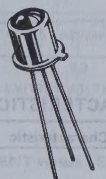
NPN SILICON HIGH SENSITIVITY PHOTO DARLINGTON TRANSISTORS

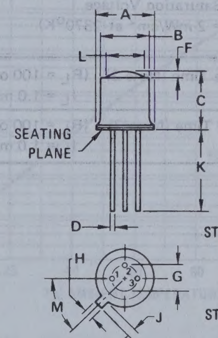
. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuit or any design requiring very high radiation sensitivity at low light levels.

- Popular TO-18 Type Hermetic Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wider Application
- Minimum Light Current 12 mA at H = 0.5 mW/cm^2 (MRD360)
- External Base for Added Control
- Switching Times –
  t_r @ I_L = 1.0 mA peak = 15 μs (Typ) – MRD370
  t_f @ I_L = 1.0 mA peak = 25 μs (Typ) – MRD370

40 VOLT
PHOTO DARLINGTON TRANSISTORS
NPN SILICON

250 MILLIWATTS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

STYLE 2:
PIN 1. CATHODE
2. GATE
3. ANODE

NOTES:
1. LEADS WITHIN .13 mm (.005) RADIUS OF TRUE POSITION AT SEATING PLANE, AT MAXIMUM MATERIAL CONDITION.
2. PIN 3 INTERNALLY CONNECTED TO CASE.

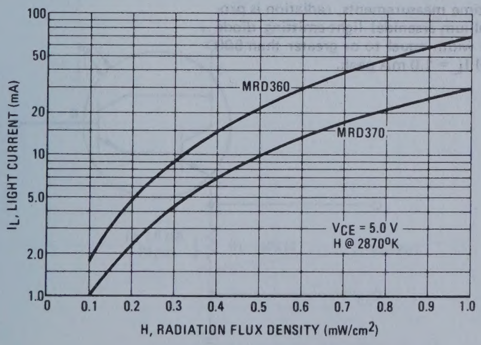
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	5.08	6.35	0.200	0.250
D	0.41	0.48	0.016	0.019
F	0.51	1.02	0.020	0.040
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
L	3.35	4.01	0.132	0.158
M	45° BSC		45° BSC	

CASE 82
TO-18

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted).

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Volts
Emitter-Base Voltage	V_{EBO}	10	Volts
Collector-Base Voltage	V_{CBO}	50	Volts
Light Current	I_L	250	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 1.43	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 – LIGHT CURRENT versus IRRADIANCE



STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CE} = 10 V, H ≈ 0) T_A = 25°C	I_{CEO}	–	10	100	nA
Collector-Base Breakdown Voltage (I_C = 100 µA)	BV_{CBO}	50	–	–	Volts
Collector-Emitter Breakdown Voltage (I_C = 100 µA)	BV_{CEO}	40	–	–	Volts
Emitter-Base Breakdown Voltage (I_E = 100 µA)	BV_{EBO}	10	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Device Type	Symbol	Min	Typ	Max	Unit
Light Current V_{CC} = 5.0 V, R_L = 10 Ohms (Note 1)	MRD360 MRD370	I_L	12 3.0	20 10	– –	mA
Collector-Emitter Saturation Voltage (I_L = 10 mA, H = 2 mW/cm² at 2870°K)		$V_{CE(sat)}$	–	–	1.0	Volts
Photo Current Rise Time (Note 2) (R_L = 100 ohms I_L = 1.0 mA peak)	MRD360 MRD370	t_r	– –	40 15	100 100	µs
Photo Current Fall Time (Note 2) (R_L = 100 ohms I_L = 1.0 mA peak)	MRD360 MRD370	t_f	– –	60 25	150 150	µs

NOTES:

1. Radiation flux density (H) equal to 0.5 mW/cm² emitted from a tungsten source at a color temperature of 2870 K.
2. For unsaturated response time measurements, radiation is provided by pulsed GaAs (gallium-arsenide) light-emitting diode (λ ≈ 0.9 µm) with a pulse width equal to or greater than 500 microseconds (see Figure 6) I_L = 1.0 mA peak.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER SATURATION CHARACTERISTIC

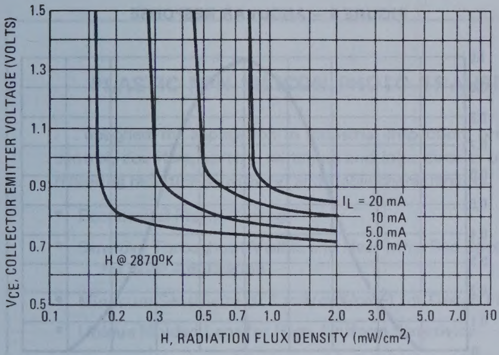


FIGURE 3 – COLLECTOR CHARACTERISTICS

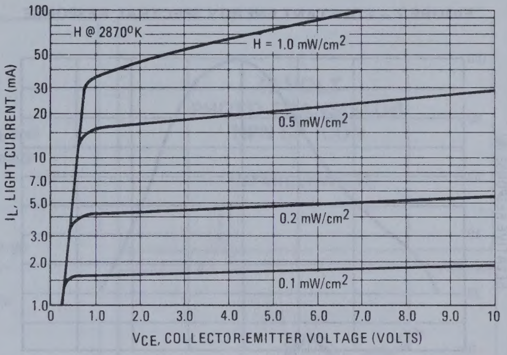


FIGURE 4 – NORMALIZED LIGHT CURRENT versus TEMPERATURE

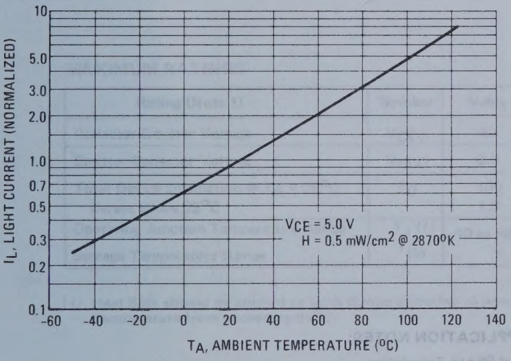


FIGURE 5 – DARK CURRENT versus TEMPERATURE

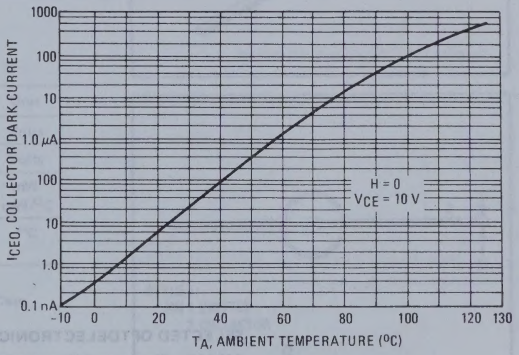


FIGURE 6 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM

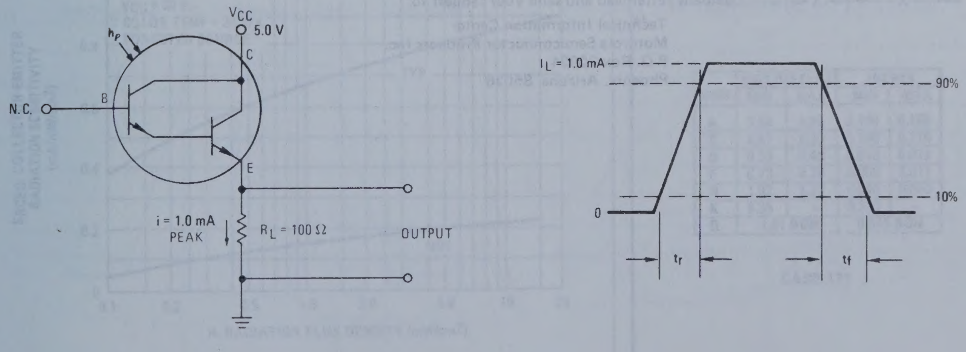

V_{CC}
5.0 V
h_P
C
B
N.C.
E
i = 1.0 mA
PEAK
R_L = 100 Ω
OUTPUT
I_L = 1.0 mA
90%
10%
0
t_r
t_f

FIGURE 7 – CONSTANT ENERGY SPECTRAL RESPONSE

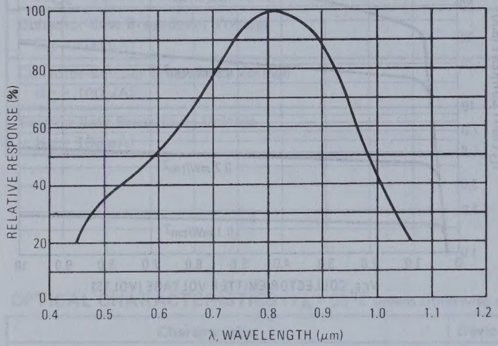
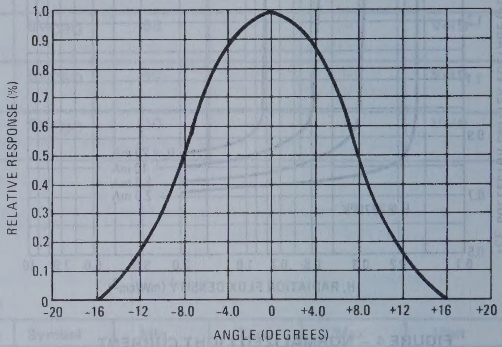


FIGURE 8 – ANGULAR RESPONSE



SELECTED OPTOELECTRONICS APPLICATION NOTES:

AN-440	Theory and Characteristics of Photo Transistors
AN-508	Applications of Phototransistors in Electro-Optic Systems.
AN-561	How to Use Photosensors and Light Sources

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products Inc.
P.O. Box 20924
Phoenix, Arizona 85036

MRD450 (SILICON)

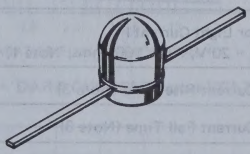
PLASTIC NPN SILICON PHOTO TRANSISTOR

. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Economical Plastic Package
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Minimum Sensitivity (0.2 mA/mW/cm^2) for Design Flexibility
- Unique Molded Lens for High, Uniform Sensitivity
- Annular Passivated Structure for Stability and Reliability

40 VOLT
PHOTO TRANSISTOR
NPN SILICON

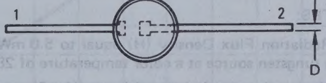
100 MILLIWATTS



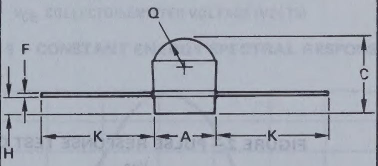
MAXIMUM RATINGS

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Volts
Emitter-Collector Voltage	V_{ECO}	6.0	Volts
Total Device Dissipation @ $T_A = 25^{\circ}C$ Derate above 25°C	P_D	100 1.3	mW mW/°C
Operating Junction Temperature Range Storage Temperature Range	T_J (1) T_{stg}	-40 to +85	°C

(1) Heat Sink should be applied to leads during soldering to prevent Case Temperature from exceeding 85°C.



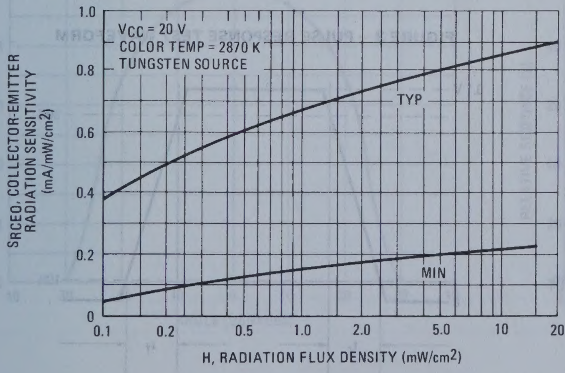
STYLE 1:
PIN 1. EMITTER
2. COLLECTOR



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.56	4.06	0.140	0.160
C	4.57	5.33	0.180	0.210
D	0.33	0.48	0.013	0.019
F	0.23	0.28	0.009	0.011
H	1.02	1.27	0.040	0.050
K	6.35	–	0.250	–
Q	1.91 NOM		0.075 NOM	

CASE 171

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY



STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, Note 2)	I_{CEO}				μA
T_A = 25°C		—	—	0.10	
T_A = 85°C		—	5.0	—	
Collector-Emitter Breakdown Voltage (I_C = 100 μA; Note 2)	BV_{CEO}	40	—	—	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA; Note 2)	BV_{ECO}	6.0	—	—	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector Light Current I (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	1	I_L	1.0	4.0	—	mA
Photo Current Rise Time (Note 3)	2 and 3	t_r	—	—	2.5	μs
Photo Current Fall Time (Note 3)	2 and 3	t_f	—	—	4.0	μs
Wavelength of Maximum Sensitivity	9	λ_s	—	0.8	—	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. ($H \approx 0$).
3. For unsaturated response time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode ($\lambda \approx 0.9$ μm) with a pulse width equal to or greater than 10 microseconds (see Figure 2 and Figure 3).

FIGURE 2 – PULSE RESPONSE TEST CIRCUIT

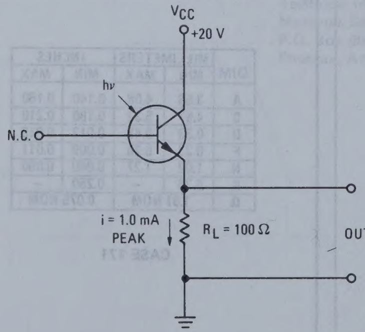
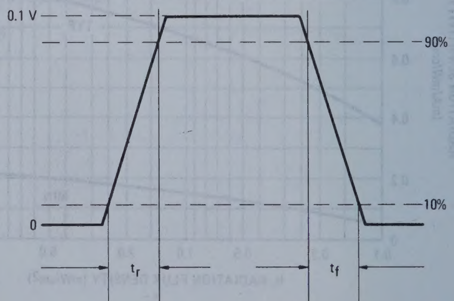


FIGURE 3 – PULSE RESPONSE TEST WAVEFORM



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 4 – COLLECTOR-EMITTER CHARACTERISTICS

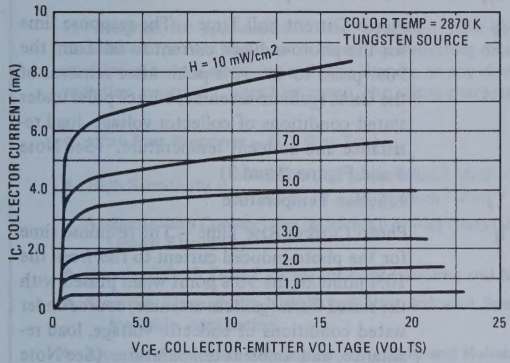


FIGURE 5 – COLLECTOR SATURATION CHARACTERISTICS

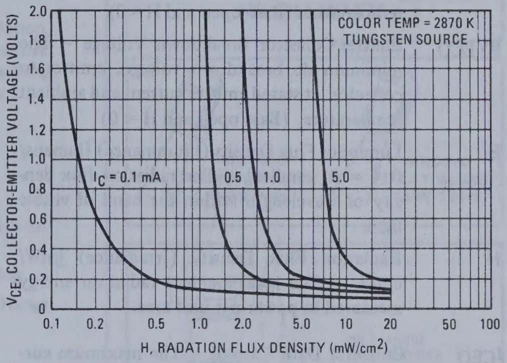


FIGURE 6 – DARK CURRENT versus TEMPERATURE

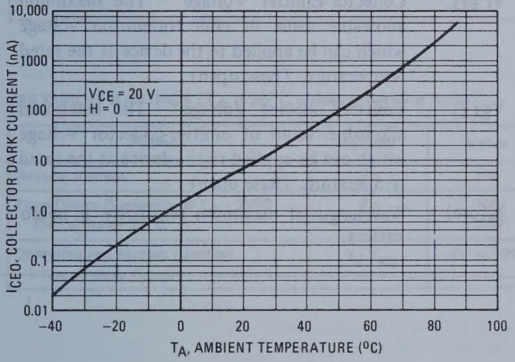


FIGURE 7 – DARK CURRENT versus VOLTAGE

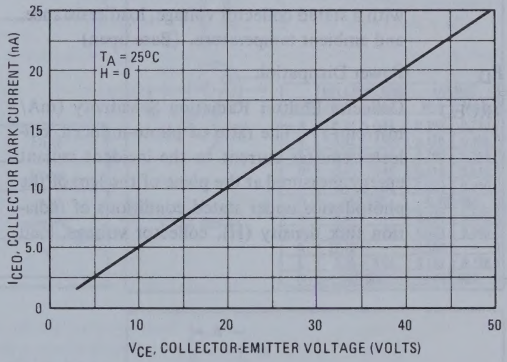


FIGURE 8 – ANGULAR RESPONSE

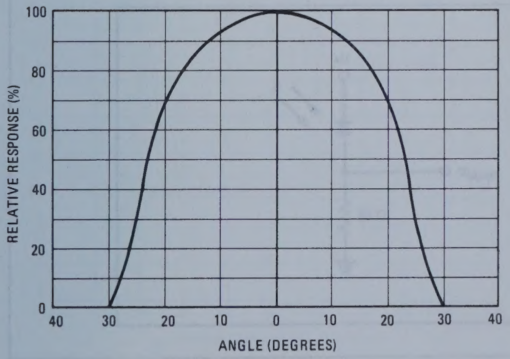
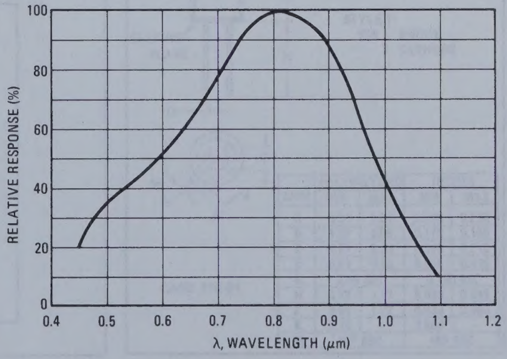


FIGURE 9 – CONSTANT ENERGY SPECTRAL RESPONSE



MRD450
OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CEO}	Collector-Emitter Breakdown Voltage – The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and H ≈0)
BV_{ECO}	Emitter-Collector Breakdown Voltage – The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and H ≈ 0)
E	Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.
H	Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.
I_{CEO}	Collector Dark Current – The maximum current through the collector terminal of the device measured under dark conditions, (H ≈ 0), with a stated collector voltage, load resistance, and ambient temperature. (Base open)
P_D	Power Dissipation
S_{RCEO}	Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) – The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)
T_A	Ambient Temperature
t_f	Photo Current Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 3 and Figures 2 and 3)
T_J	Junction Temperature
t_r	Photo Current Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 3 and Figures 2 and 3)
V_{CEO}	Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)
V_{ECO}	Emitter-Collector Voltage – The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)
λ_s(μm)	Wavelength of maximum sensitivity in micro meters.

MRD500 (SILICON)
MRD510

PIN SILICON PHOTO DIODE

. . . designed for application in laser detection, light demodulation, detection of visible and near infrared light-emitting diodes, shaft or position encoders, switching and logic circuits, or any design requiring radiation sensitivity, ultra high-speed, and stable characteristics.

- Ultra Fast Response – (<1.0 ns Typ)
- High Sensitivity – MRD500 (1.2 μA/mW/cm² Min)
  MRD510 (0.3 μA/mW/cm² Min)
- Available With Convex Lens (MRD500) or Flat Glass (MRD510) for Design Flexibility
- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wide Application
- Annular Passivated Structure for Stability and Reliability

100 VOLT
PHOTO DIODE
PIN SILICON

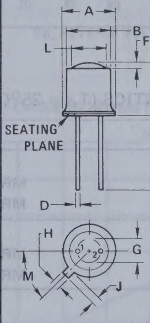
100 MILLIWATTS

MRD500
(CONVEX LENS)
CASE 209-1

MRD510
(FLAT GLASS)
CASE 210-1

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 0.57	mW mW/°C
Operating and Storage Junction Temperature Range	T_J T_{stg}	-65 to +200	°C



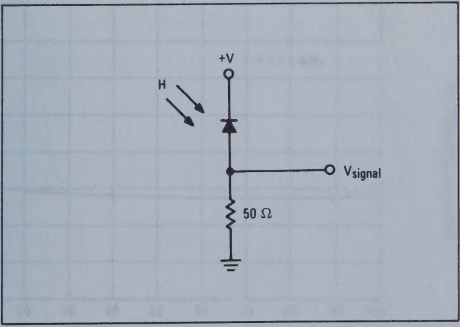
PIN 1. ANODE
PIN 2. CATHODE

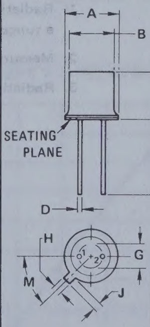
PIN 2 INTERNALLY CONNECTED TO CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	5.08	6.35	0.200	0.250
D	0.41	0.48	0.016	0.019
F	0.51	1.02	0.020	0.040
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
L	3.35	4.01	0.132	0.158
M	45° BSC		45° BSC	

CASE 209-01

FIGURE 1 – TYPICAL OPERATING CIRCUIT





STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.57	5.33	0.180	0.210
D	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
M	45° BSC		45° BSC	

CASE 210-01

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Dark Current (V_R = 20 V, R_L = 1.0 megohm; Note 2) T_A = 25°C T_A = 100°C	4 and 5	I_D	— —	— 14	2.0 —	nA
Reverse Breakdown Voltage (I_R = 10 µA)	—	BV_R	100	200	—	Volts
Forward Voltage (I_F = 50 mA)	—	V_F	—	—	1.1	Volts
Series Resistance (I_F = 50 mA)	—	R_s	—	—	10	ohms
Total Capacitance (V_R = 20 V; f = 1.0 MHz)	6	C_T	—	—	4	pF

OPTICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Radiation Sensitivity (V_R = 20 V, Note 1) MRD500 MRD510	2 and 3	S_R	1.2 0.3	1.8 0.42	— —	µA/mW/cm^2
Sensitivity at 0.8 µm (V_R = 20 V, Note 3) MRD500 MRD510	— —	$S(\lambda = 0.8\ \mu m)$	—	6.6 1.5	— —	µA/mW/cm^2
Response Time (V_R = 20 V, R_L = 50 ohms)	— —	$t_{(resp)}$	—	1.0	—	ns
Wavelength of Peak Spectral Response	7	λ_s	—	0.8	—	µm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. Radiation Flux Density (H) equal to 0.5 mW/cm^2 at 0.8 µm.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD500

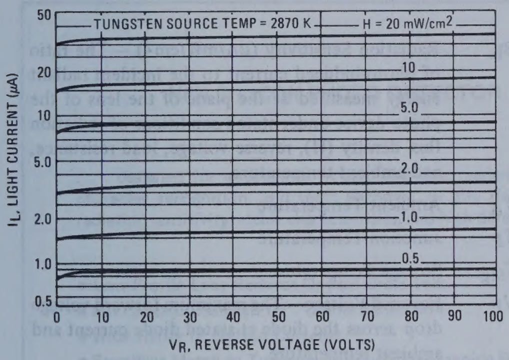


FIGURE 3 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD 510

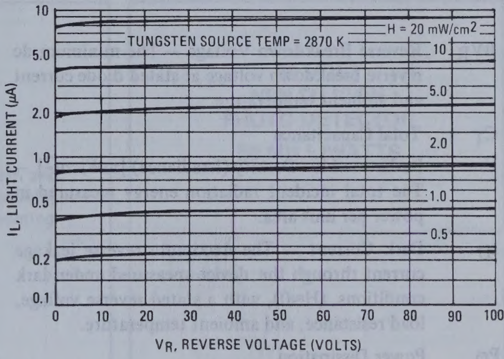


FIGURE 4 – DARK CURRENT versus TEMPERATURE

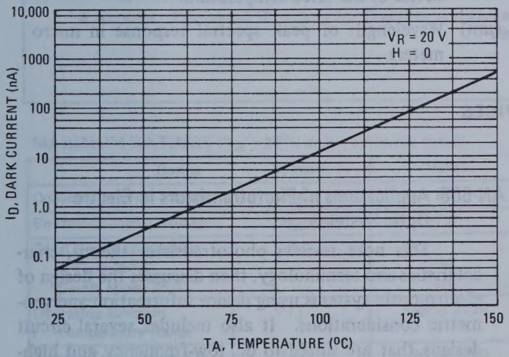


FIGURE 5 – DARK CURRENT versus REVERSE VOLTAGE

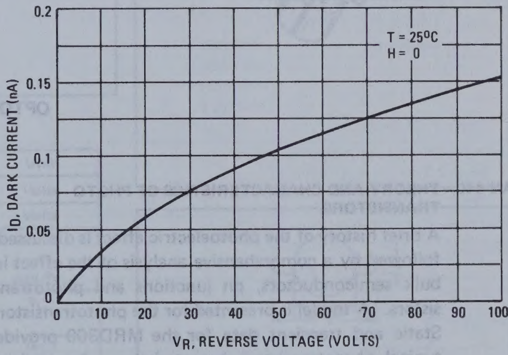


FIGURE 6 – CAPACITANCE versus VOLTAGE

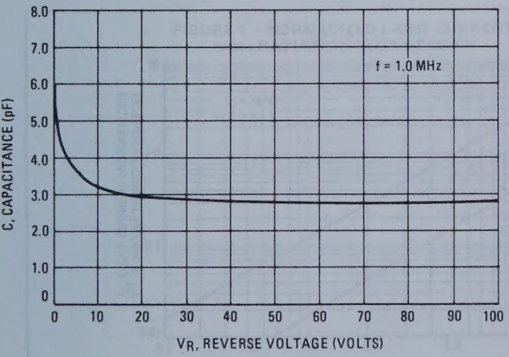
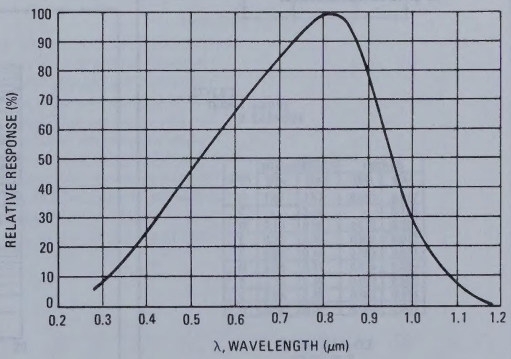


FIGURE 7 – RELATIVE SPECTRAL RESPONSE



MRD500 AND MRD510 OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_R	Reverse Breakdown Voltage – The minimum dc reverse breakdown voltage at stated diode current and ambient temperature.
C_T	Total Capacitance
H	Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.
I_D	Dark Current – The maximum reverse leakage current through the device measured under dark conditions, (H≈0), with a stated reverse voltage, load resistance, and ambient temperature.
P_D	Power Dissipation
R_s	Series Resistance – The maximum dynamic series resistance measured at stated forward current and ambient temperature.
S_R	Radiation Sensitivity (μA/mW/cm^2) – The ratio of photo-induced current to the incident radiant energy measured at the plane of the lens of the photo device under stated conditions of radiation flux density (H), reverse voltage, load resistance, and ambient temperature.
T_A	Ambient Temperature
T_J	Junction Temperature
T_{stg}	Storage Temperature
V_F	Forward Voltage – The maximum forward voltage drop across the diode at stated diode current and ambient temperature.
V_R	Reverse Voltage – The maximum allowable value of dc reverse voltage which can be applied to the device at the rated temperature.
$\lambda_s(\mu m)$	Wavelength of peak spectral response in micro meters.

OPTO DEVICES

AN-440 – THEORY AND CHARACTERISTICS OF PHOTO TRANSISTORS

A brief history of the photoelectric effect is discussed, followed by a comprehensive analysis of the effect in bulk semiconductors, pn junctions and phototransistors. A model is presented for the phototransistor. Static and transient data for the MRD300 provide typical phototransistor characteristics. Appendices provide a discussion of the relationship of irradiation and illumination and define terms specifically related to phototransistors.

AN-508 Applications of Phototransistors in Electro-Optic Systems

This note reviews phototransistor theory, characteristics and terminology, then discusses the design of electro-optic systems using device information and geometric considerations. It also includes several circuit designs that are suited to dc, low-frequency and high-frequency applications.

MRD601, MRD602 (SILICON)
MRD603, MRD604

NPN SILICON PHOTO DETECTOR

. . . designed for application in card and tape readers, pattern and character recognition, and shaft encoders, or any design requiring radiation sensitivity, stable characteristics, and high-density mounting.

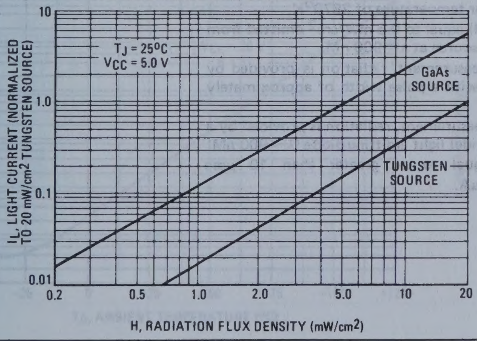
- Low Profile Lens Reduces Optical Cross-Talk
- Pill Package Designed for PC Board Insertion
- Wide Range of Output Currents
- Excellent Match to Tungsten and Gallium-Arsenide Sources
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wider Application
- Rugged Hermetic Package
- Annular Passivated Structure for Stability and Reliability

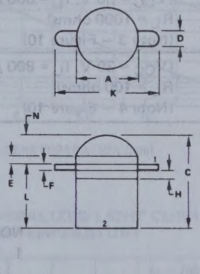
50 VOLT
NPN SILICON
PHOTO DETECTOR
50 MILLIWATTS

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 50 0.5	 mW mW/°C
Operating Junction Temperature Range	T_J	–65 to +125	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C
Soldering Temperature		240°C for 10 seconds	

FIGURE 1 – NORMALIZED LIGHT CURRENT versus RADIATION FLUX DENSITY





STYLE 2:
TERM 1. ANODE
2. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.47	1.57	0.058	0.062
C	–	3.18	–	0.125
D	0.46	0.56	0.018	0.022
E	0.20	0.30	0.008	0.012
F	0.08	0.18	0.003	0.007
H	0.36	0.51	0.014	0.020
K	2.11	2.36	0.083	0.093
L	2.08	2.39	0.082	0.094
N	0.58	0.79	0.023	0.031

CASE 81A-03
STYLE 2

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)		Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 30 V, H = 0)	T_A = 25°C	I_{CEO}	–	–	25	nA
	T_A = 100°C		–	1.0	–	µA
Collector-Emitter Breakdown Voltage (I_C = 100 µA, H = 0)		BV_{CEO}	50	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 µA, H = 0)		BV_{ECO}	7.0	–	–	Volts

ELECTRO-OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Light Current (V_{CC} = 5.0 V, R_L = 100 ohms, H = 20 mW/cm^2	MRD601	I_L	0.5	1.5	–	mA
	MRD602		2.0	3.5	–	
	MRD603		4.0	6.0	–	
	MRD604		7.0	8.5	–	
(Note 1 – Figure 1)						
Light Current (V_{CC} = 5.0 V, R_L = 100 ohms, H = 0.5 mW/cm^2)	MRD601	I_L	–	0.08	–	mA
	MRD602		–	0.18	–	
	MRD603		–	0.30	–	
	MRD604		–	0.45	–	
(Note 2 – Figure 1)						
Collector-Emitter Saturation Voltage (I_C = 0.5 mA, H = 20 mW/cm^2) (Note 1 – Figure 2)		$V_{CE(sat)}$	–	0.13	–	Volts
Rise Time	(V_{CC} = 30 V, I_L = 800 µA, R_L = 1000 ohms) (Note 3 – Figure 10)	t_r	–	1.5	–	µs
Fall Time		t_f	–	15	–	µs
Rise Time	(V_{CC} = 30 V, I_L = 800 µA, R_L = 100 ohms) (Note 4 – Figure 10)	t_r	–	2.0	–	µs
Fall Time		t_f	–	2.8	–	µs

NOTES:

1. Radiation Flux Density (H) equal to 20 mW/cm^2 emitted from a tungsten source at a color temperature of 2870°K.
2. Radiation Flux Density (H) equal to 0.5 mW/cm^2 emitted from a GaAs (gallium-arsenide) source at $\lambda \approx$ 900 nM.
3. For this response time measurement, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 µs (see Figure 10).
4. For this response time measurement, radiation is provided by a pulsed GaAs (gallium arsenide) light emitting diode ($\lambda \approx$ 900 nM) with a pulse width equal to or greater than 10 µsec (see Figure 10), I_L = 800 µA.

TYPICAL CHARACTERISTICS

COLLECTOR-EMITTER SATURATION VOLTAGE versus RADIATION FLUX DENSITY

FIGURE 2 – SATURATION CHARACTERISTICS WITH TUNGSTEN SOURCE

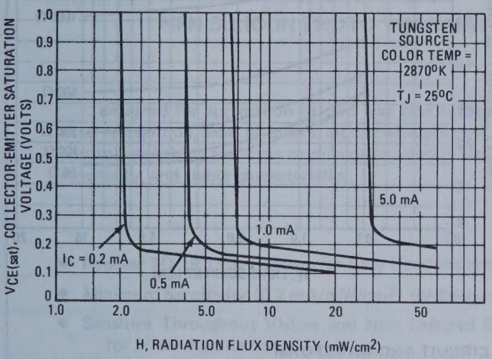
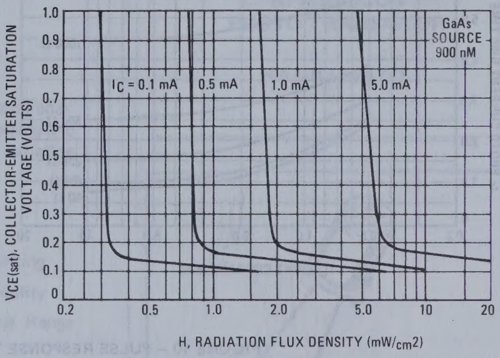


FIGURE 3 – SATURATION CHARACTERISTICS WITH GaAs SOURCE



COUPLING CHARACTERISTICS WITH GaAs SOURCE

FIGURE 4 – CONTINUOUS LIGHT CURRENT versus DISTANCE

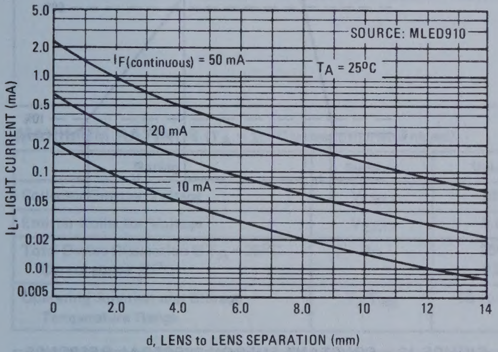


FIGURE 5 – PULSED LIGHT CURRENT versus DISTANCE

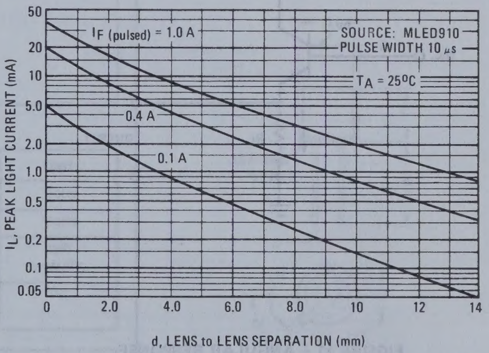


FIGURE 6 – DARK CURRENT versus TEMPERATURE

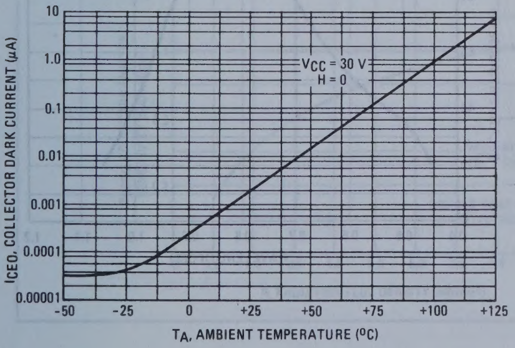


FIGURE 7 – NORMALIZED LIGHT CURRENT versus TEMPERATURE

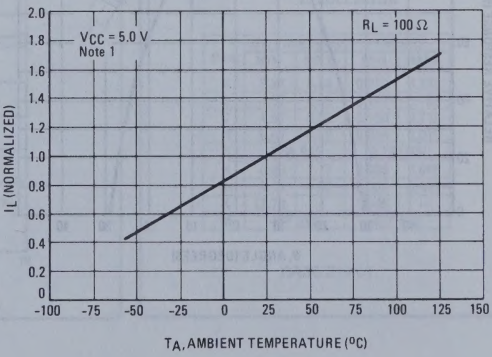


FIGURE 8 – RISE TIME versus LIGHT CURRENT

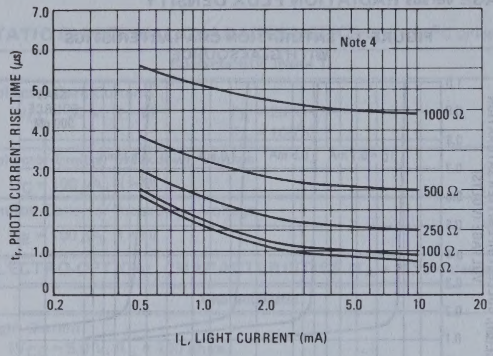


FIGURE 9 – FALL TIME versus LIGHT CURRENT

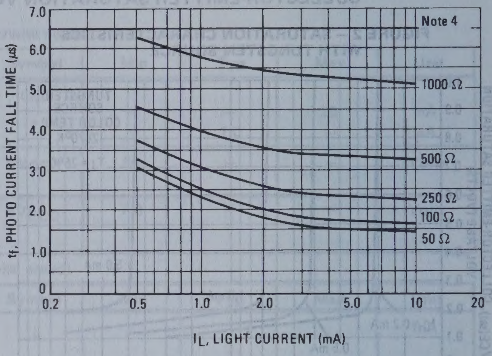


FIGURE 10 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM

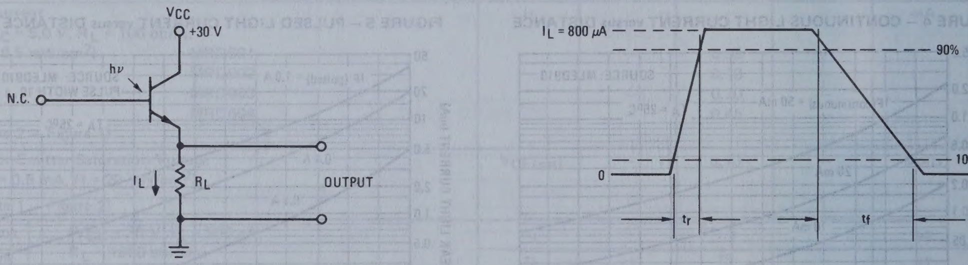

VCC
+30 V
hν
N.C.
I_L
R_L
OUTPUT
I_L = 800 μA
90%
10%
0
t_r
t_f

FIGURE 11 – ANGULAR RESPONSE

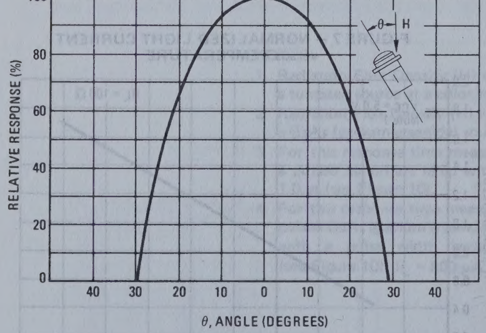
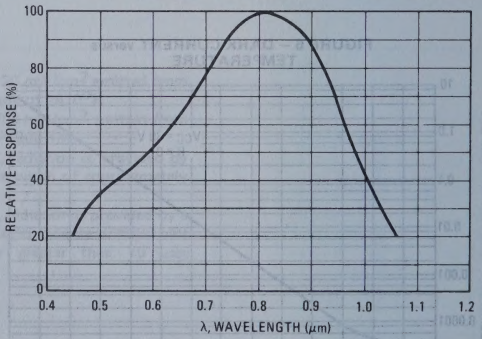


FIGURE 12 – CONSTANT ENERGY SPECTRAL RESPONSE



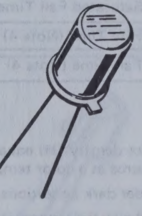
MRD810 (SILICON)

NPN SILICON PHOTO TRANSISTOR

. . . designed for application in card and tape readers, optical character recognition, shaft encoders, industrial inspection, processing and control, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Popular TO-18 Type Package for Easy Handling and Mounting
- Minimum Sensitivity (0.2 mA/mW/cm^2) for Design Flexibility
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wider Application
- Annular Passivated Structure for Stability and Reliability
- Flat Lens for Fiber Optic Coupling
- Precision Die Location for Minimum Optical Tolerances

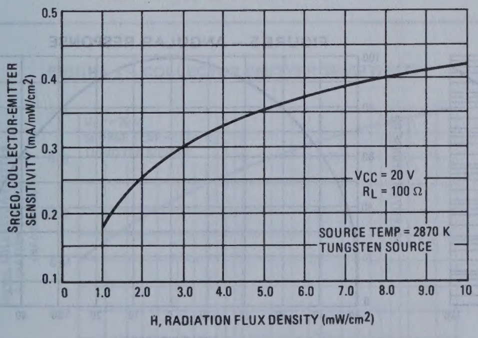
35 VOLTS
NPN SILICON
PHOTO TRANSISTOR
250 MILLIWATTS

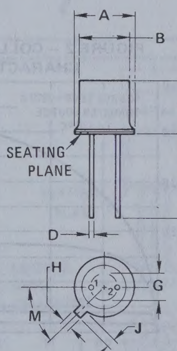


MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Volts
Emitter-Collector Voltage	V_{ECO}	5.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.5	mW mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-55 to +125	°C

FIGURE 1 — COLLECTOR-EMITTER SENSITIVITY versus RADIATION FLUX DENSITY





STYLE 2:
PIN 1. EMITTER
2. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.57	5.33	0.180	0.210
D	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
M	45° BSC		45° BSC	

CASE 210-01

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, R_L = 100 ohms, Note 2) T_A = 25°C T_A = 100°C	I_{CEO}	— —	— 10	0.050 —	μA
Collector-Emitter Breakdown Voltage (I_C = 100 μA, Note 2)	BV_{CEO}	35	50	—	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA, Note 2)	BV_{ECO}	5.0	8.0	—	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Light Current (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	I_L	1.0	—	—	mA
Photo Current Saturated Rise Time (Note 3)	$t_{r(sat)}$	—	2.0	—	μs
Photo Current Saturated Fall Time (Note 3)	$t_{f(sat)}$	—	25	—	μs
Photo Current Rise Time (Note 4)	t_r	—	—	5.0	μs
Photo Current Fall Time (Note 4)	t_f	—	—	6.0	μs

NOTES:

1. Radiation flux density (H) equal to 5.0 mW/cm² emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 2).
4. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ≈0.9 μm) with a pulse width equal to or greater than 20 microseconds.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

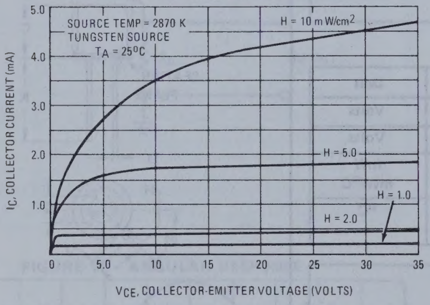


FIGURE 3 – COLLECTOR SATURATION CHARACTERISTICS

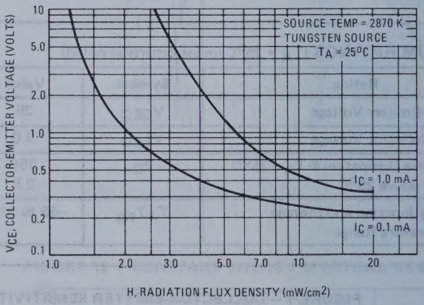


FIGURE 4 – DARK CURRENT versus TEMPERATURE

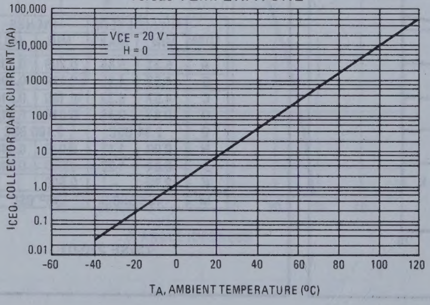
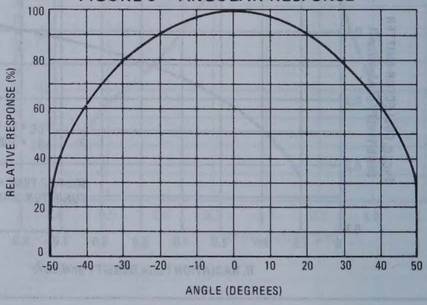


FIGURE 5 – ANGULAR RESPONSE



MRD3050 (SILICON)
thru
MRD3056

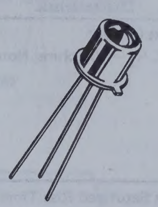
NPN SILICON PHOTO TRANSISTOR

. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Hermetic Package at Economy Prices
- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wider Application
- Range of Radiation Sensitivities for Design Flexibility
- External Base for Added Control
- Annular Passivated Structure for Stability and Reliability

30 VOLT
NPN SILICON
PHOTO TRANSISTOR

400 MILLIWATTS



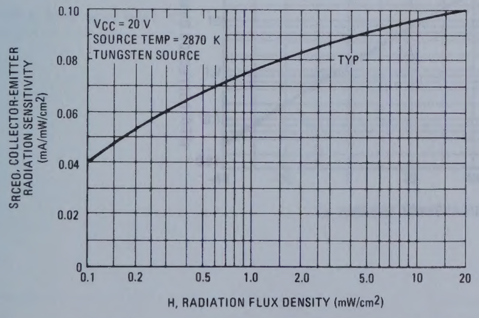
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

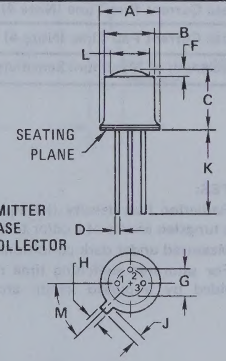
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Volts
Emitter-Collector Voltage	V_{ECO}	5.0	Volts
Collector-Base Voltage	V_{CBO}	40	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	438	°C/W

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NOTES:
1. LEADS WITHIN .13 mm (.005) RADIUS OF TRUE POSITION AT SEATING PLANE, AT MAXIMUM MATERIAL CONDITION.
2. PIN 3 INTERNALLY CONNECTED TO CASE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	5.08	6.35	0.200	0.250
D	0.41	0.48	0.016	0.019
F	0.51	1.02	0.020	0.040
G	2.54 BSC		0.100 BSC	
H	0.99	1.17	0.039	0.046
J	0.84	1.22	0.033	0.048
K	12.70	–	0.500	–
L	3.35	4.01	0.132	0.158
M	45° BSC		45° BSC	

CASE 82-01

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current	I_{CEO}				µA
(V_{CC} = 20 V, R_L = 1.0 Megohm, Note 2) T_A = 25°C		—	—	0.1	
T_A = 85°C		—	5.0	—	
Collector-Base Breakdown Voltage (I_C = 100 µA)	BV_{CBO}	40	—	—	Volts
Collector-Emitter Breakdown Voltage (I_C = 100 µA)	BV_{CEO}	30	—	—	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 µA)	BV_{ECO}	5.0	—	—	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector Light Current (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	1	I_L				mA
MRD3050			0.10	—	—	
MRD3051			0.20	—	—	
MRD3052			0.10	—	0.40	
MRD3053			0.25	—	1.0	
MRD3054			0.625	—	2.5	
MRD3055			1.5	—	—	
MRD3056			2.0	—	—	
Photo Current Saturated Rise Time (Note 3)	4	$t_{r(sat)}$	—	1.0	—	µs
Photo Current Saturated Fall Time (Note 3)	4	$t_{f(sat)}$	—	10	—	µs
Photo Current Rise Time (Note 4)	4	t_r	—	2.0	—	µs
Photo Current Fall Time (Note 4)	4	t_f	—	3.5	—	µs
Wavelength of Maximum Sensitivity	—	λ_s	—	0.8	—	µm

NOTES:

1. Radiation flux density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. For saturated switching time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4).
4. For unsaturated switching time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ≈0.9 µm) with a pulse width equal to or greater than 10 microseconds (see Figure 4).

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

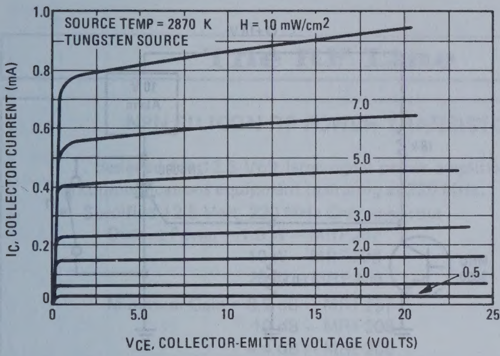


FIGURE 3 – PHOTO CURRENT versus TEMPERATURE

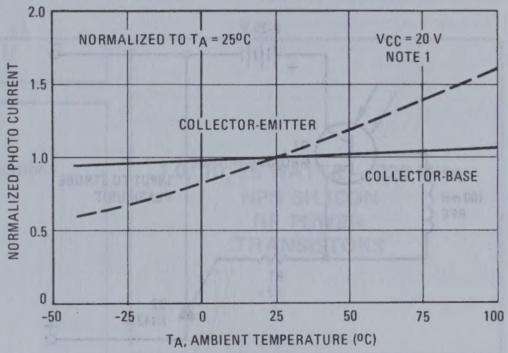


FIGURE 4 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM

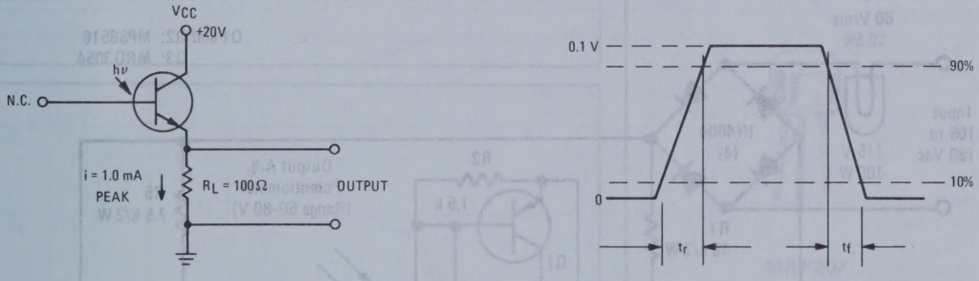
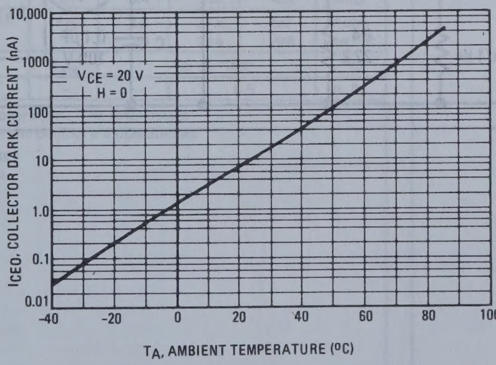

VCC
+20V
hν
N.C.
i = 1.0 mA
PEAK
RL = 100Ω
OUTPUT
0.1 V
90%
10%
0
tr
tf

FIGURE 5 – DARK CURRENT versus TEMPERATURE



TYPICAL CIRCUIT APPLICATIONS

(Extracted from Motorola Applications Note AN-508, "Applications of Phototransistors in Electro-Optic Systems")

FIGURE 6 — STROBEFLASH SLAVE ADAPTER

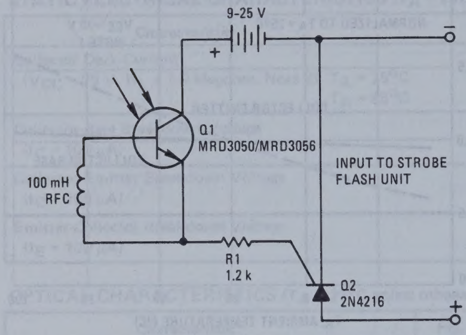

9-25 V
+
−
Q1
MRD3050/MRD3056
INPUT TO STROBE FLASH UNIT
100 mH
RFC
R1
1.2 k
Q2
2N4216
+

FIGURE 7 — LIGHT OPERATED SCR ALARM USING SENSITIVE-GATE SCR

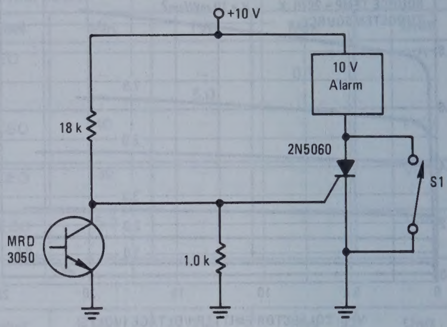
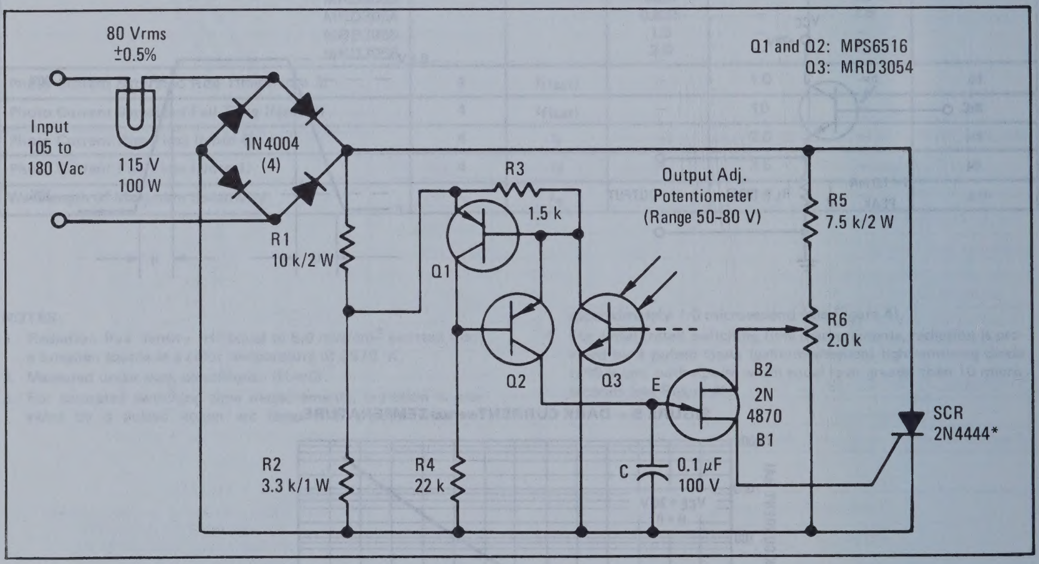

+10 V
10 V
Alarm
18 k
2N5060
S1
MRD
3050
1.0 k

FIGURE 8 — CIRCUIT DIAGRAM OF VOLTAGE REGULATOR FOR PROJECTION LAMP.


80 Vrms
±0.5%
Q1 and Q2: MPS6516
Q3: MRD3054
Input
105 to
180 Vac
115 V
100 W
1N4004
(4)
R3
1.5 k
Output Adj.
Potentiometer
(Range 50-80 V)
R5
7.5 k/2 W
R1
10 k/2 W
Q1
R6
2.0 k
Q2
Q3
E
B2
2N
4870
B1
SCR
2N4444*
R2
3.3 k/1 W
R4
22 k
C
0.1 μF
100 V

*2N4444 to be used with a heat sink.

MRF207, MRF208, MRF209 (SILICON)

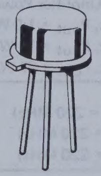
The RF Line

NPN SILICON RF POWER TRANSISTORS

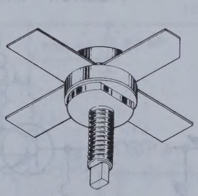
. . . designed for 12.5 Volt large-signal power amplifier applications in communications equipment operating at 220 MHz.

- Specified 12.5 Volt, 220 MHz Characteristics —
  Output Power = 1.0 W — MRF207
  10 W — MRF208
  25 W — MRF209
  Minimum Gain = 8.2 dB — MRF207
  10 dB — MRF208
  4.4 dB — MRF209
- Balanced-Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch.

1.0, 10, 25 WATTS — 220 MHz
NPN SILICON
RF POWER
TRANSISTORS



MRF207



MRF208
MRF209

MAXIMUM RATINGS

Rating	Symbol	MRF207	MRF208	MRF209	Unit
Collector-Emitter Voltage	V_{CEO}	← 18 →			Vdc
Collector-Base Voltage	V_{CBO}	← 36 →			Vdc
Emitter-Base Voltage	V_{EBO}	← 4.0 →			Vdc
Collector Current — Continuous	I_C	0.4	2.0	4.0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C^{(1)}$ Derate above 25°C	P_D	3.5 20	37.5 214	50 286	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200			°C
Stud Torque$^{(2)}$	—	—	6.5		in. lb.

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

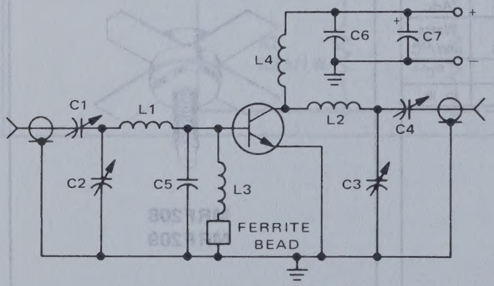
(2) For Repeated Assembly use 5 in. lb.

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 5.0 mAdc, I_B = 0)	MRF207		18	—	—	
(I_C = 15 mAdc, I_B = 0)	MRF208		18	—	—	
(I_C = 20 mAdc, I_B = 0)	MRF209		18	—	—	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 2.0 mAdc, I_E = 0)	MRF207		36	—	—	
(I_C = 5.0 mAdc, I_E = 0)	MRF208		36	—	—	
(I_C = 10 mAdc, I_E = 0)	MRF209		36	—	—	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	MRF207		4.0	—	—	
(I_E = 2.5 mAdc, I_C = 0)	MRF208		4.0	—	—	
(I_E = 5.0 mAdc, I_C = 0)	MRF209		4.0	—	—	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 15 Vdc, I_E = 0)	MRF207		—	—	0.1	
	MRF208		—	—	0.25	
	MRF209		—	—	0.5	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MRF207		5.0	—	—	
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	MRF208		5.0	—	—	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	MRF209		5.0	—	—	
FUNCTIONAL TESTS						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(V_{CC} = 12.5 Vdc, P_{out} = 1.0 W, f = 220 MHz)	MRF207		8.2	12.5	—	
(V_{CC} = 12.5 Vdc, P_{out} = 10 W, f = 220 MHz)	MRF208		10	12.5	—	
(V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 220 MHz)	MRF209		4.4	5.2	—	
Input Impedance		Z_{in}				Ohms
(P_{out} = 1.0 W, f = 220 MHz)	MRF207		—	10-j11.5	—	
(P_{out} = 10 W, f = 220 MHz)	MRF208		—	1.4+j1.4	—	
(P_{out} = 25 W, f = 220 MHz)	MRF209		—	1.4+j1.8	—	
Output Impedance		Z_{out}				Ohms
(P_{out} = 1.0 W, f = 220 MHz)	MRF207		—	32 - j41	—	
(P_{out} = 10 W, f = 220 MHz)	MRF208		—	5.7 - j1.3	—	
(P_{out} = 25 W, f = 220 MHz)	MRF209		—	3.9 - j0.2	—	

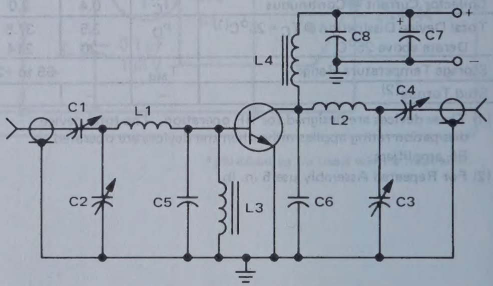
220 MHz TEST CIRCUIT

FIGURE 1 – MRF207



C1	2.0 - 50 pF	ARCO 461
C2, C4	5.0 - 80 pF	ARCO 462
C3	1.5 - 15 pF	ARCO 460
C5	40 pF	
C6	1000 pF	
C7	5.0 µF	TANTALUM
L1	1 Turn, #20 AWG, 1/4″ ID	
L2	4 Turns, #20 AWG, 1/4 ID	
L3, L4	15 µH RFC	

FIGURE 2 – MRF208, MRF209



C1, C2, C3, C4	5.0 - 80 pF	ARCO 462
C5, C6	100 pF	
C7	10 µF	TANTALUM
C8	1000 pF	
L1	#14 AWG, 1¼″ Long, Straight	
L2	1 Turn, #14 AWG, 3/8″ ID	
L3, L4	RFC VK200	

OUTPUT POWER versus INPUT POWER
(V_{CC} = 12.5 Vdc, f = 220 MHz)

FIGURE 3 – MRF207

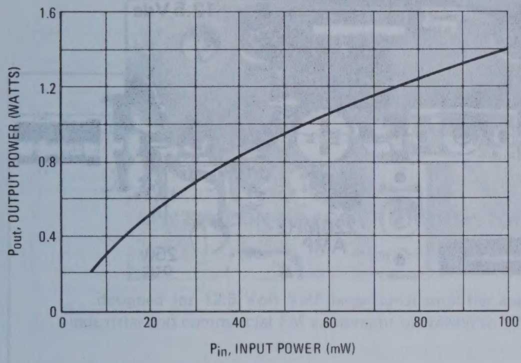


FIGURE 4 – MRF208

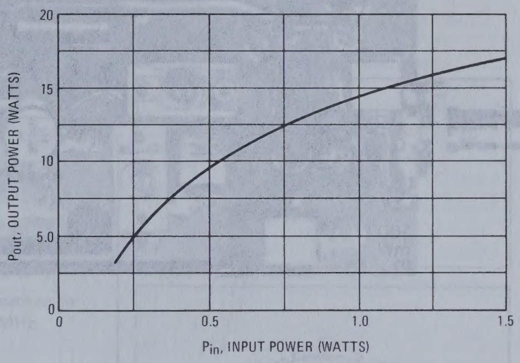


FIGURE 5 – MRF209

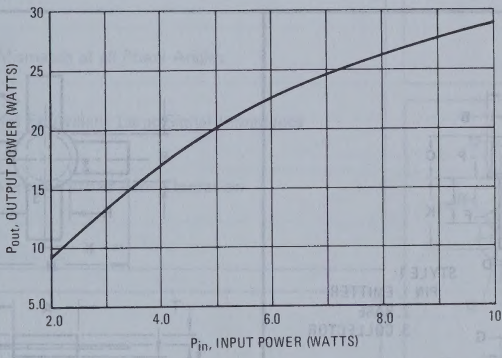


FIGURE 6 – 220-MHz, 25-WATT AMPLIFIER

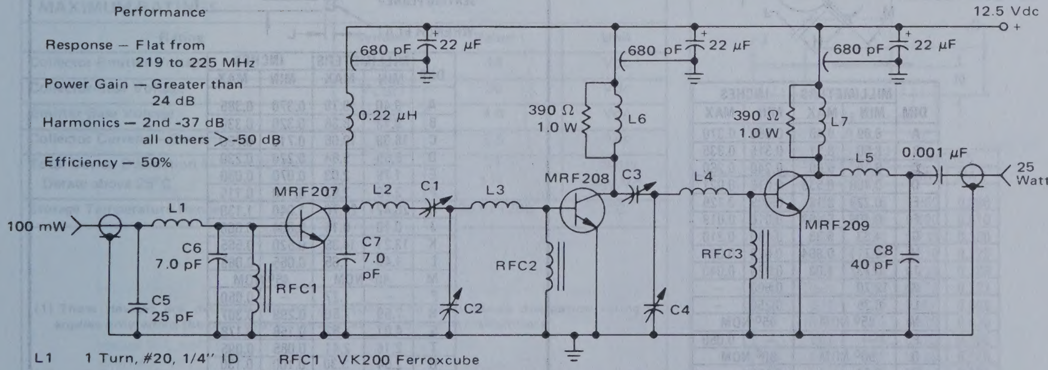
Performance

Response – Flat from 219 to 225 MHz

Power Gain – Greater than 24 dB

Harmonics – 2nd -37 dB
all others >-50 dB

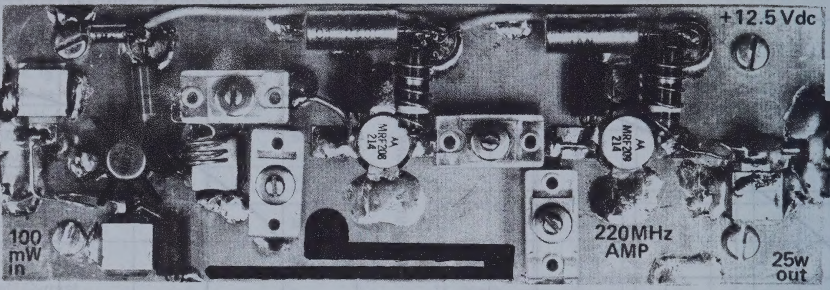
Efficiency – 50%

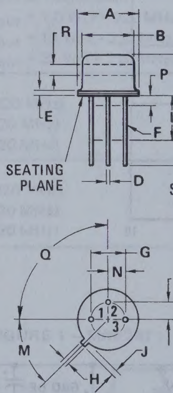

12.5 Vdc
+
680 pF
22 µF
680 pF
22 µF
680 pF
22 µF
0.22 µH
390 Ω
1.0 W
L6
390 Ω
1.0 W
L7
L5
0.001 µF
25 Watts
MRF207
L2
C1
L3
MRF208
C3
L4
MRF209
L1
100 mW
C6
7.0 pF
C7
7.0 pF
RFC1
C5
25 pF
RFC2
C2
RFC3
C4
C8
40 pF

L1	1 Turn, #20, 1/4″ ID
L2	3 Turns, #20, 1/4″ ID
L3	1/3 Turn, #16, 3/8″ ID
L4	1/3 Turn, #18, 1/4″ ID
L5	1 Turn, #20, 1/8″ ID
L6,L7	5 Turns, #20, 1/4″ ID

RFC1	VK200 Ferroxcube
RFC2	VK200 Ferroxcube
RFC3	VK200 Ferroxcube

C1	2.0-25 pF, ARCO 421 or equivalent
C2,C3,C4	7.0-100 pF, ARCO, 423 or equivalent
C8	Underwood or equivalent capacitor which is capable of high current without undue heating.


+12.5 Vdc
MRF208 214
MRF209 214
100 mW in
220MHz AMP
25w out

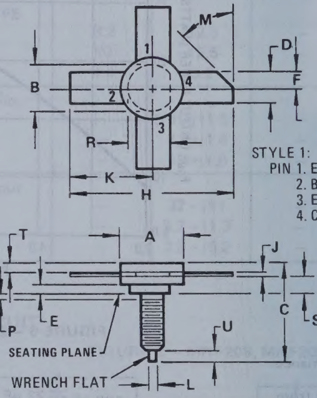

A
R
B
P
C
E
L
F
K
SEATING PLANE
D
Q
G
N
N
1
2
3
M
J
H

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39


M
D
1
B
2
4
F
3
L
R
K
H
T
A
J
E
C
S
P
U
SEATING PLANE
WRENCH FLAT
L

STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

MRF215 (SILICON)

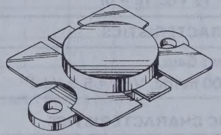
The RF Line

NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt VHF large-signal amplifier applications in industrial and commercial FM equipment operating to 175 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 20 Watts
  Minimum Gain = 8.2 dB
  Efficiency = 60%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broad Band Operation

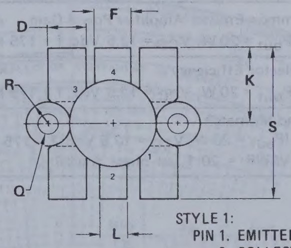
20 W – 175 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON



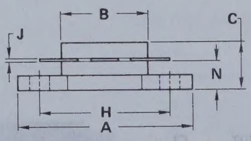
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	31 177	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE – ISOLATED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.59	0.210	0.220
F	5.59	5.84	0.220	0.230
H	18.24	18.59	0.718	0.732
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	4.45	4.70	0.175	0.185
N	4.06	4.45	0.160	0.175
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

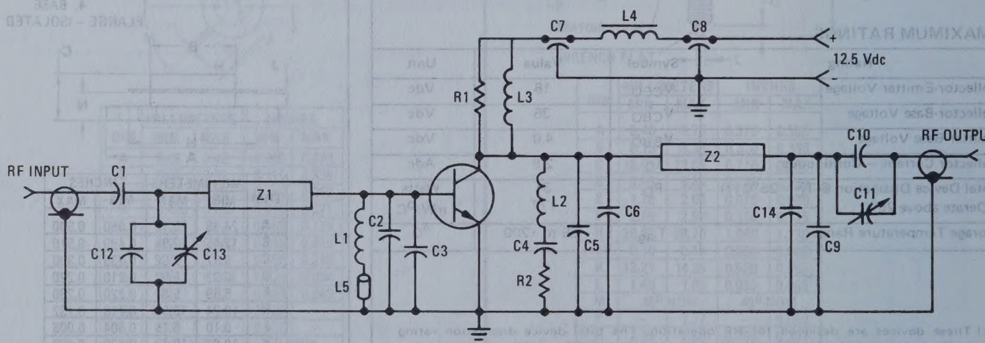
NOTE:
1. DIM. "K" FROM CENTER OF "Q".

CASE 278-04

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	18		–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	8.0	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	70	85	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	8.2	–	–	dB
Collector Efficiency (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	60			%
Load Mismatch (P_{out} = 20 W, V_{CC} = 12.5 Vdc, f = 175 MHz VSWR = 20:1, all phase angles)	–	No Degradation in Output Power			

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1,C12	15 pF UNDERWOOD
C2,C3	40 pF UNDERWOOD
C4	0.1 µF, 100 V, ERIE
C5,C6,C10,C14	10 pF UNDERWOOD
C7,C8	680 pF ALLEN BRADLEY Feedthrough
C9	25 pF UNDERWOOD
C11,C13	1.0-10 pF JOHANSEN Type 3201
L1	0.15 µH Choke
L2	2 Turns, #24 AWG, 1/8″ ID

L3	6 Turns, #20 AWG, on 390 Ohm, 2 W Resistor
L4	Ferrite Choke, FERROXCUBE VK-200-10-4B
L5	Ferrite Bead, FERROXCUBE 56-590-65-3B
R1	390 Ohm, 1/2 W, 10%
R2	2.7 Ohm, 1/4 W, 10%
Z1, Z2	MICROSTRIPLINE – 0.275″ W x 4.13″ L

Board – Glass Teflon, ε = 2.56, t = 0.062″
Input/Output Connectors – Type N

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

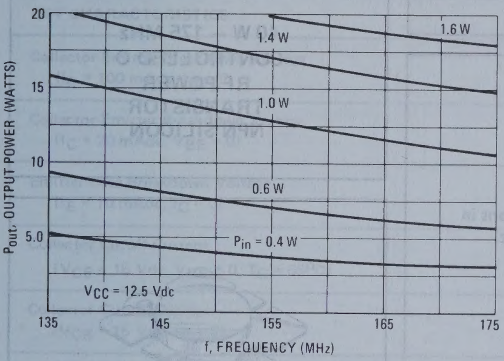


FIGURE 3 – OUTPUT POWER versus INPUT POWER

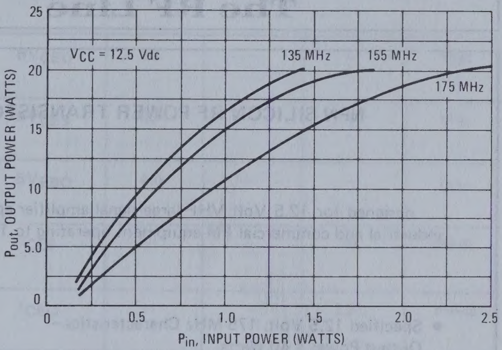


FIGURE 4 – TYPICAL GAIN versus FREQUENCY

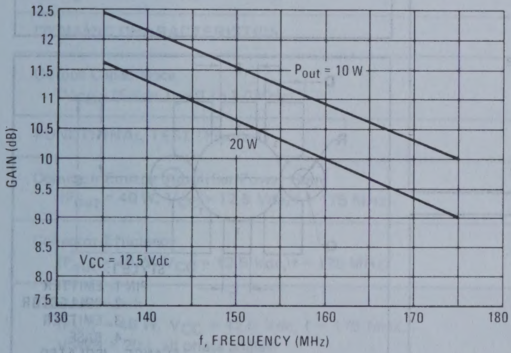
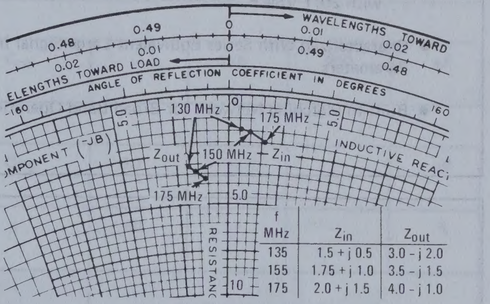
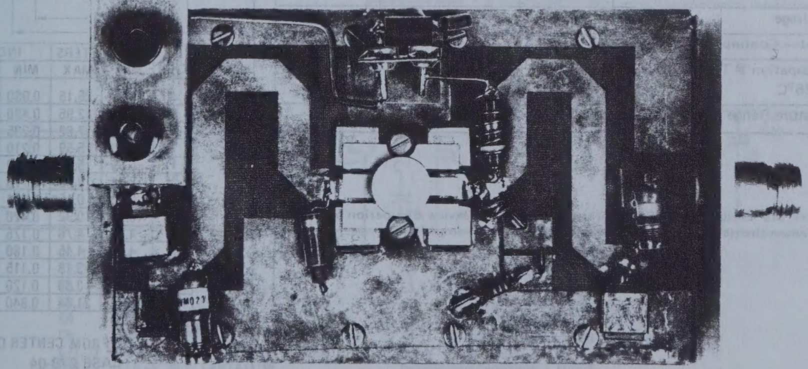


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



f MHz	Z_{in}	Z_{out}
135	1.5 + j 0.5	3.0 – j 2.0
155	1.75 + j 1.0	3.5 – j 1.5
175	2.0 + j 1.5	4.0 – j 1.0

FIGURE 6 – 175 MHz TEST CIRCUIT LAYOUT



MRF216 (SILICON)

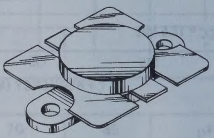
The RF Line

NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt VHF large-signal amplifier applications in industrial and commercial FM equipment operating to 175 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics—
  Output Power = 40 Watts
  Minimum Gain = 6.7 dB
  Efficiency = 60%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broad Band Operation

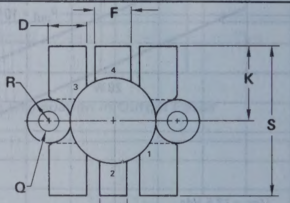
40 W – 175 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON



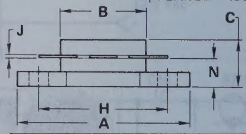
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	6.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	75 0.428	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE – ISOLATED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.33	5.59	0.210	0.220
F	5.59	5.84	0.220	0.230
H	18.24	18.59	0.718	0.732
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	4.45	4.70	0.175	0.185
N	4.06	4.45	0.160	0.175
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

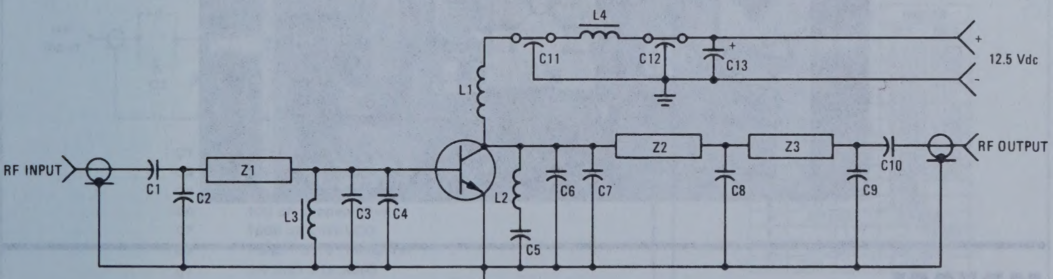
NOTE:
1. DIM. "K" FROM CENTER OF "Q".

CASE 278-04

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_C = 55^{\circ}C$)	I_{CES}	–	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	2.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	170	200	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	6.7	–	–	dB
Collector Efficiency (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	60	–	–	%
Load Mismatch (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz, VSWR = 20:1, all phase angles)	–	No Degradation in Output Power			

FIGURE 1 — 175 MHz TEST CIRCUIT SCHEMATIC



C1, 10	0.1 μF, 100 V Chip
C2, 3, 4	40 pF, UNELCO
C5	0.1 μF, 100 V Disc Ceramic
C6, 7	10 pF, UNELCO
C8	25 pF, UNELCO
C9	60 pF, UNELCO
C11, 12	680 pF, ALLEN BRADLEY Feedthru
C13	1.0 μF, 35 V, TANTALUM

L1	6 Turns, #18 AWG, 1/4″ Dia.
L2	3 Turns, 1/8″ Dia on Lead of C5
L3, L4	FERRITE Choke. FERROXCUBE VK200-10-4B
Z1	MICROSTRIPLINE, 0.300″ Wide, 3.20″ Long
Z2	MICROSTRIPLINE, 0.300″ Wide, 0.50″ Long
Z3	MICROSTRIPLINE, 0.300″ Wide, 1.90″ Long

Board – Glass Teflon, ϵ = 2.56, t = 0.062″
Input/Output Connectors – Type N

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

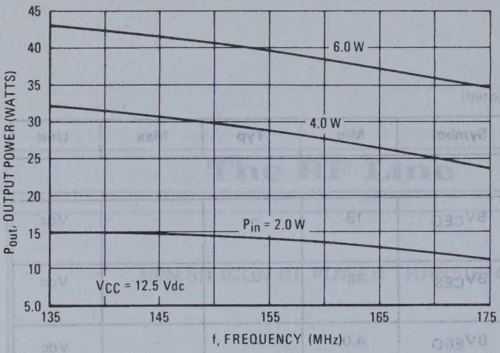


FIGURE 3 – OUTPUT POWER versus INPUT POWER

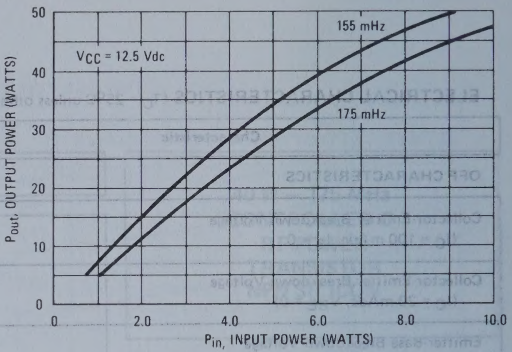


FIGURE 4 – TYPICAL GAIN versus FREQUENCY

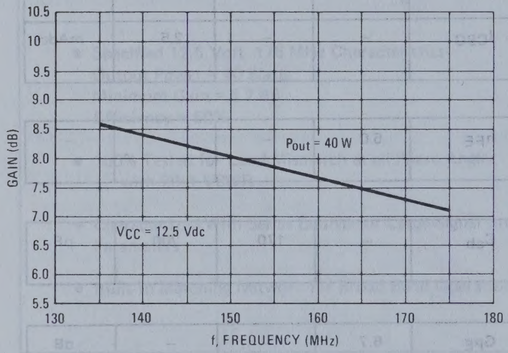
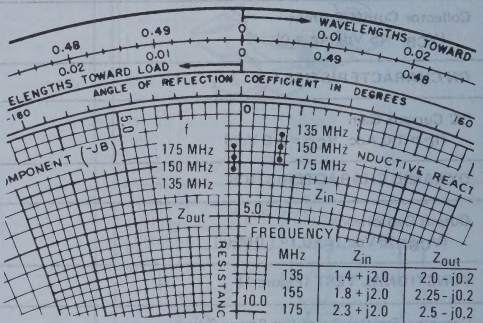
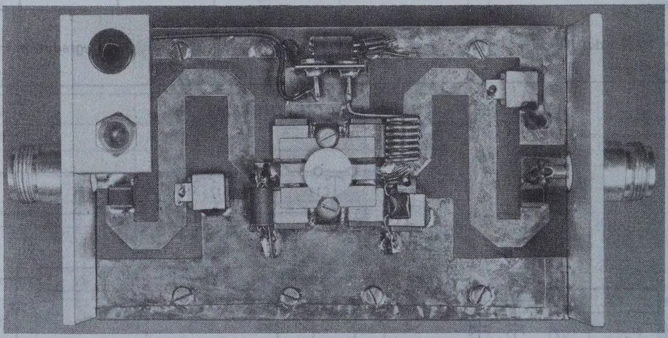


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



FREQUENCY MHz	Z_{in}	Z_{out}
135	1.4 + j2.0	2.0 - j0.2
155	1.8 + j2.0	2.25 - j0.2
175	2.3 + j2.0	2.5 - j0.2

FIGURE 6 – 175 MHz TEST CIRCUIT LAYOUT



MRF221 (SILICON)

For Specifications, See 2N6081 Data, Volume II.

MRF225 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt large-signal power amplifier applications in communication equipment operating at 225 MHz. Ideally suited for Class E citizens band radio.

- Specified 12.5 Volt, 225 MHz Characteristics –
  Output Power = 1.5 Watts
  Minimum Gain = 9.0 dB
  Efficiency = 50%
- Characterized With Series Equivalent Large-Signal Impedance Parameters

1.5 W — 225 MHz

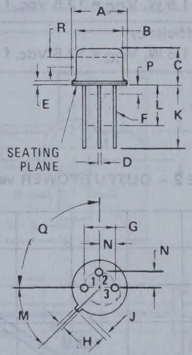
RF POWER TRANSISTOR

NPN SILICON

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	0.25	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	3.5 0.02	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.



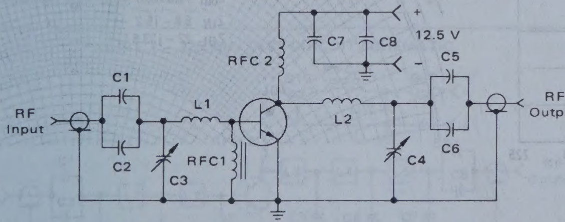
STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 – 225 MHz TEST CIRCUIT SCHEMATIC



C1,2,5	50 pF Dipped Mica
C3	1.5-20 pF ARCO 402
C4	4.0-40 pF ARCO 403
C6	100 pF Dipped Mica
C7	1000 pF UNELCO
C8	1.0 μF 35 V Tantalum
L1	0.6 Inch #18 AWG
L2	2 Turns x 0.25 inch ID #18 AWG
RFC 1	Ferroxcube VK200
RFC 2	2.2 μH Molded Choke

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	15	150	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
FUNCTIONAL TEST (Figure 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 1.5 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	G_{PE}	9.0	–	dB
Collector Efficiency (P_{out} = 1.5 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	η	50	–	%

FIGURE 2 – OUTPUT POWER versus INPUT POWER

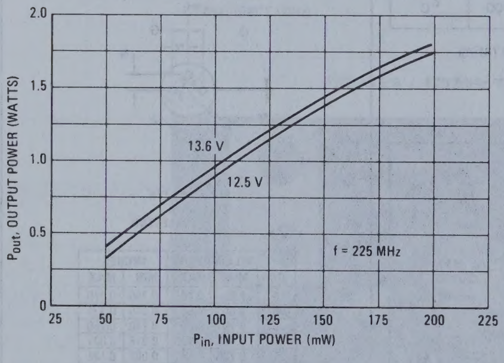
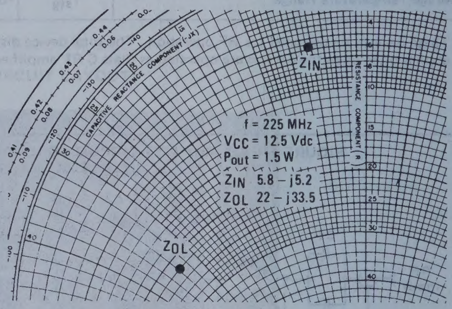


FIGURE 3 – SERIES EQUIVALENT IMPEDANCE



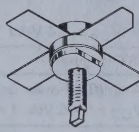
MRF226 (SILICON)

The RF Line

13 W – 225 MHz

RF POWER TRANSISTOR

NPN SILICON



NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt large-signal power amplifier applications in communication equipment operating at 225 MHz. Ideally suited for Class E citizens band radio.

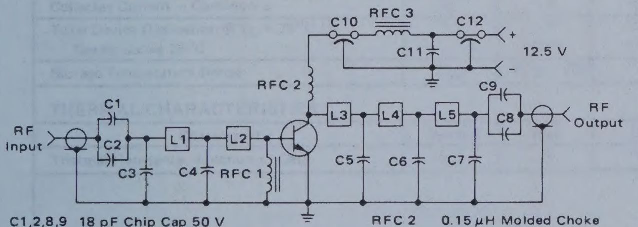
- Specified 12.5 Volt, 225 MHz Characteristics –
  Output Power = 13 Watts
  Minimum Gain = 9.0 dB
  Efficiency = 50%
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Designed to Withstand Load Mismatch at all Phase Angles with 20:1 VSWR

MAXIMUM RATINGS

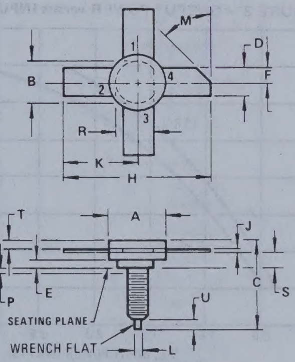
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.5	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ (1) Derate above $25^{\circ}C$	P_D	45 257	Watts $mW/^{\circ}C$
Storage Temperature Range	T_{stg}	-65 to +200	$^{\circ}C$
Stud Torque (2)	–	6.5	In. Lb.

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.
(2) For repeated assembly, use 5 In. Lb.

FIGURE 1 – 225 MHz TEST CIRCUIT SCHEMATIC



C1,2,8,9	18 pF Chip Cap 50 V	RFC 2	0.15 µH Molded Choke
C3	15 pF UNELCO	L1	0.15 x 3.15 inch Microstrip
C4,5	80 pF UNELCO	L2	0.15 x 0.55 inch Microstrip
C6	25 pF UNELCO	L3	0.15 x 1.4 inch Microstrip
C7	7.0 pF UNELCO	L4	0.15 x 2.35 inch Microstrip
C10,12	680 pF Feedthru ALLEN BRADLEY	L5	0.15 x 0.5 inch Microstrip
C11	1.0 µF, 35 V Tantalum	Board is G10 3 x 5 x 0.062 inch	
RFC 1,3	Ferroxcube VK200	$\epsilon_R = 5$	



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Emitter Breakdown Voltage (I_C = 15 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	BV_{CBO}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.5 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.25	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–
FUNCTIONAL TEST (Figure 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 13 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	G_{PE}	9.0	–	dB
Collector Efficiency (P_{out} = 13 W, V_{CC} = 12.5 Vdc, f = 225 MHz)	η	50	–	%

FIGURE 2 – OUTPUT POWER versus INPUT POWER

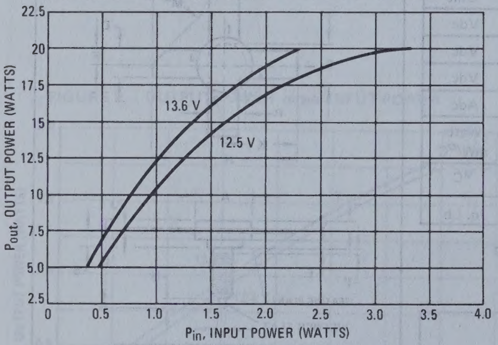
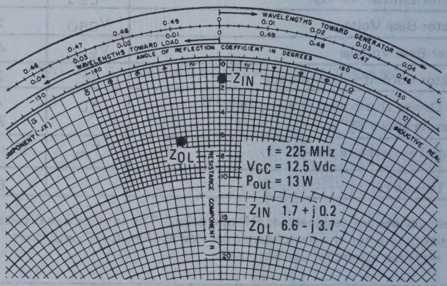


FIGURE 3 – SERIES EQUIVALENT IMPEDANCE



MRF230 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTORS

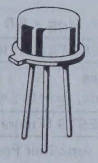
. . . designed for 12.5 Volt, mid-band large-signal amplifier applications in industrial and commercial FM equipment operating in the 40 to 100 MHz range.

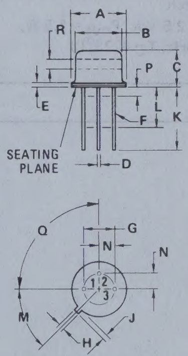
- Specified 12.5 Volt, 90 MHz Characteristics —
  Output Power = 1.5 Watts
  Minimum Gain = 10 dB
  Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Characterized with Parallel Equivalent Large-Signal Impedance Parameters

1.5 W — 90 MHz

RF POWER TRANSISTOR

NPN SILICON





STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

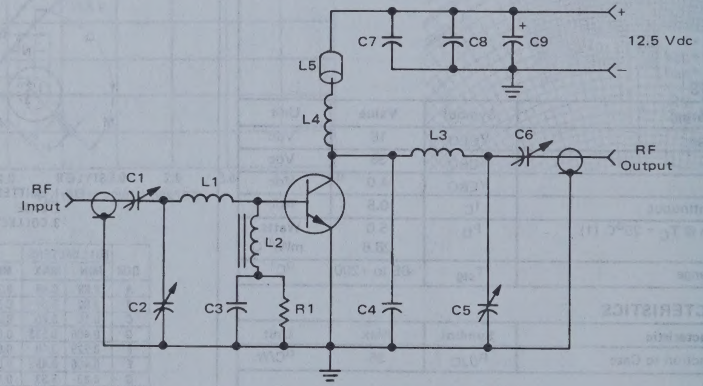
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	25	pF
FUNCTIONAL TESTS (Figure 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz)	G_{PE}	10	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz)	η	55	–	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 1.5 W, f = 90 MHz, $T_C \leqslant$ 25°C)	–	VSWR $>$ 30:1 Through All Phase Angles in 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits		

FIGURE 1 – 90 MHz TEST CIRCUIT SCHEMATIC



C1	5.0-80 pF, ARCO 462
C2,C6	25-280 pF, ARCO 464
C3	250 pF UNELCO
C4	10 pF UNELCO
C5	9.0-180 pF, ARCO 463
C7	1000 pF UNELCO
C8	0.47 µF ERIE Disc Ceramic
C9	20 µF, 15 Vdc TANTALUM
L1	2 Turns, #18 AWG, 3/8" I.D. 3/8" Long
L2	2.5 Turns, #20 AWG, on Ferrite Bead. FERROXCUBE 56-590-65-3B
L3	3 Turns, #18 AWG, 3/8" I.D., 1/2" Long
L4	0.68 µH, 9230-16 MILLER Molded Choke
L5	Ferrite Bead, FERROXCUBE 56-590-65-3B
R1	4.7 OHM, 1/2 W, 10% Carbon

Input/Output Connectors – Type BNC

FIGURE 2 – OUTPUT POWER versus INPUT POWER

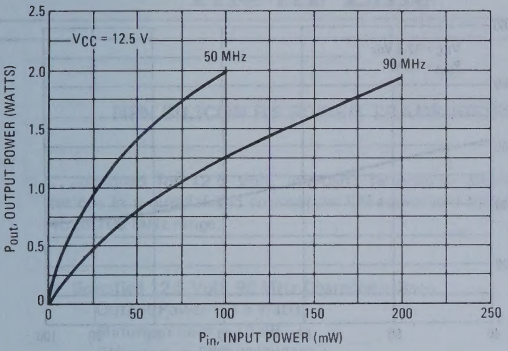


FIGURE 3 – OUTPUT POWER versus FREQUENCY

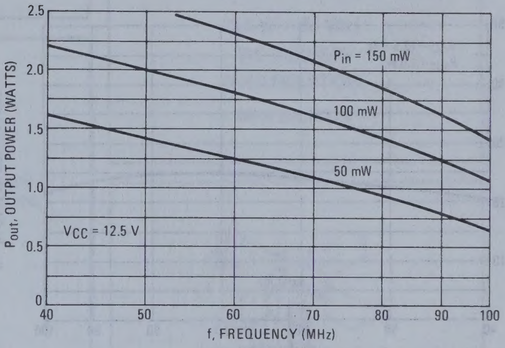


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

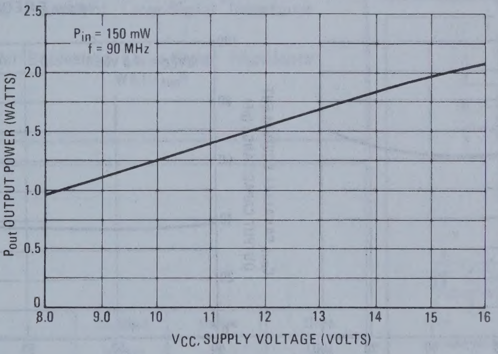
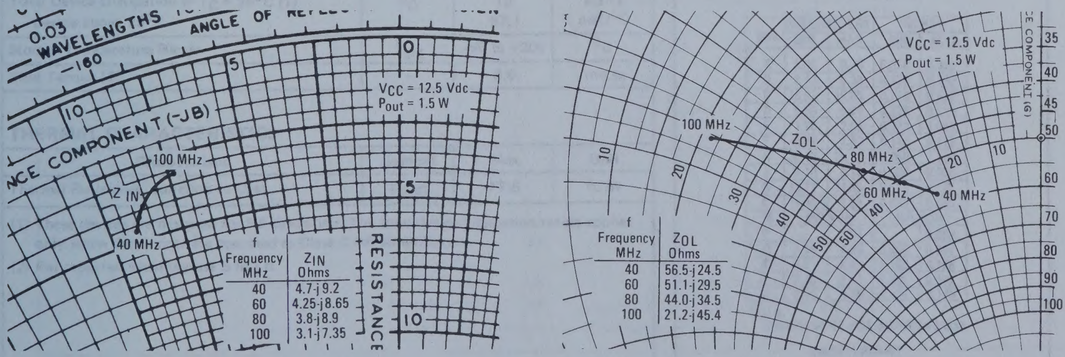


FIGURE 5

SERIES EQUIVALENT INPUT IMPEDANCE **SERIES EQUIVALENT OUTPUT IMPEDANCE**



f Frequency MHz	Z_{IN} Ohms
40	4.7-j9.2
60	4.25-j8.65
80	3.8-j8.9
100	3.1-j7.35

f Frequency MHz	Z_{OL} Ohms
40	56.5-j24.5
60	51.1-j29.5
80	44.0-j34.5
100	21.2-j45.4

FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

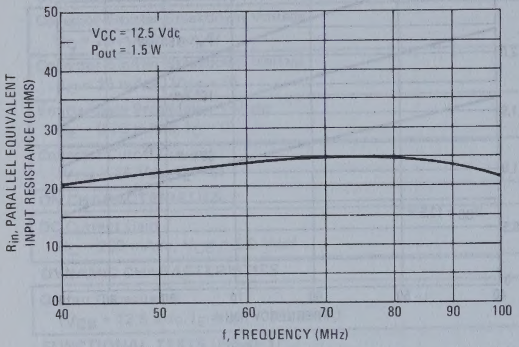


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

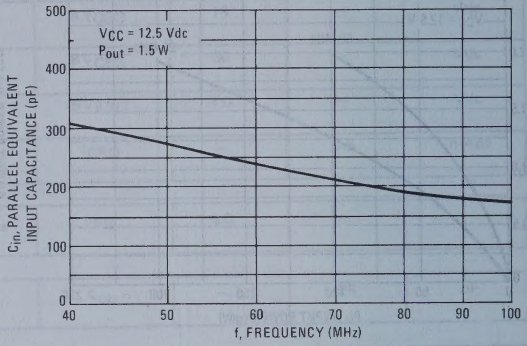


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

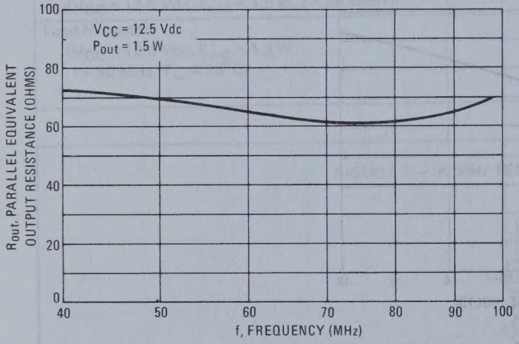
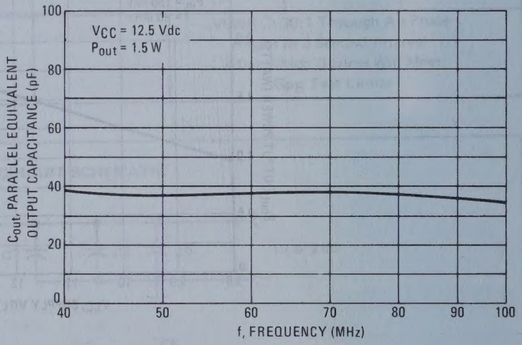


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



MRF231 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTORS

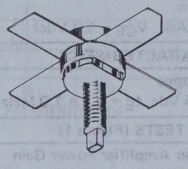
. . . designed for 12.5 Volt, mid-band large-signal amplifier applications in industrial and commercial FM equipment operating in the 40 to 100 MHz range.

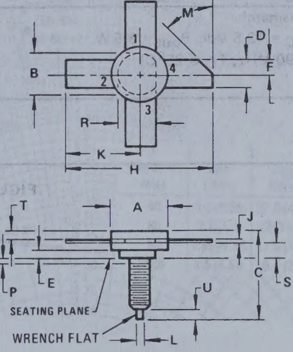
- Specified 12.5 Volt, 90 MHz Characteristics –
  Output Power = 3.5 Watts
  Minimum Gain = 10 dB
  Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Characterized with Parallel Equivalent Large-Signal Impedance Parameters

3.5 W – 90 MHz

RF POWER
TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ (1) Derate above 25°C	P_D	10 57.1	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque (2)	–	6.5	In-Lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	17.5	°C/W

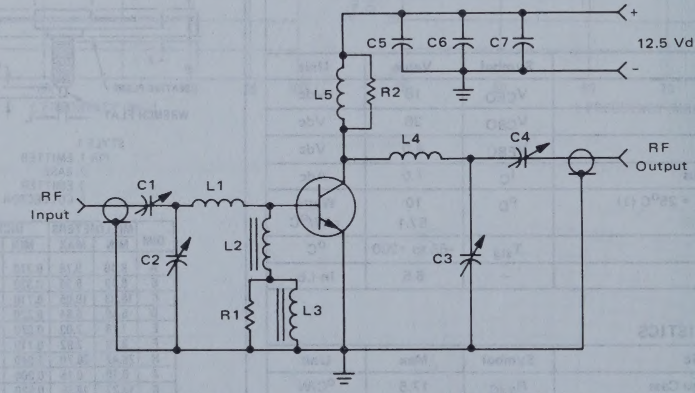
(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

(2) For repeated assembly use 5 In-Lb.

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	25	pF
FUNCTIONAL TESTS (Figure 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 3.5 W, f = 90 MHz)	G_{PE}	10	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 3.5 W, f = 90 MHz)	η	55	–	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 3.5 W, f = 90 MHz, $T_C \leqslant 25^{\circ}C$)	–	VSWR >30:1 Through All Phase Angles in 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits		

FIGURE 1 – 90 MHz TEST CIRCUIT SCHEMATIC



C1,C3	9.0-180 pF, ARCO 463
C2,C4	25-280 pF, ARCO 464
C5	1000 pF, UNELCO
C6	0.047 μF, ERIE Disc Ceramic
C7	10 μF, 15 Vdc TANTALUM
L1	2 Turns, #18 AWG, 3/8″ I.D., 1/2″ Long
L2	22 μH, 9230-52 MILLER Molded Choke
L3	1.5 μH, 9230-24 MILLER Molded Choke
L4	3 Turns, #18 AWG, 3/8″ I.D., 1/2″ Long
L5	10 Turns, Wound on R2
R1	15 Ohm, 1/2 W, 10% Carbon
R2	220 Ohm, 1 W, Carbon

Input/Output Connectors – Type BNC

FIGURE 2 – OUTPUT POWER versus INPUT POWER

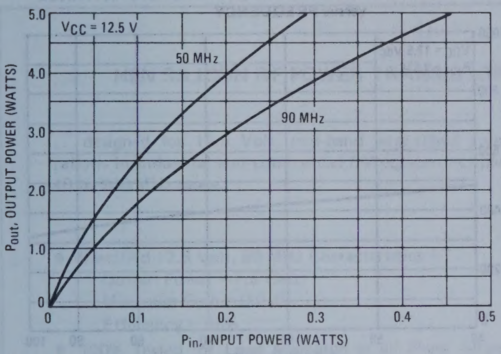


FIGURE 3 – OUTPUT POWER versus FREQUENCY

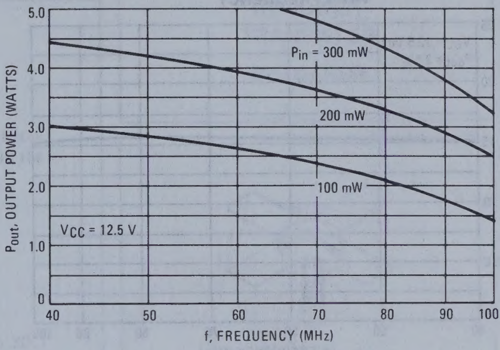


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

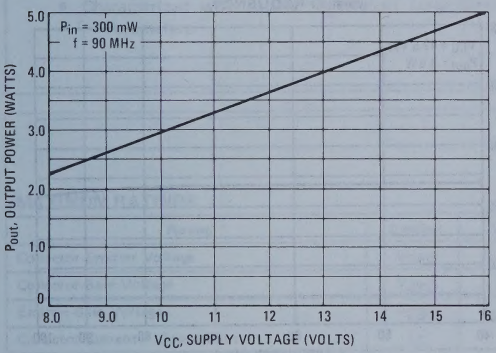
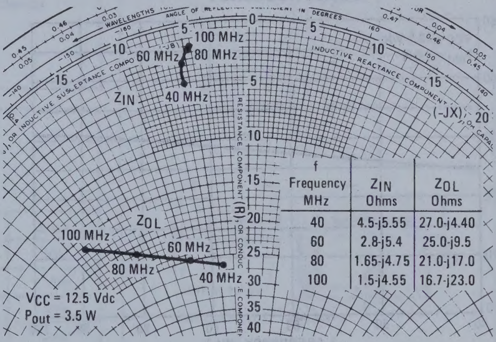


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



f Frequency MHz	Z_{IN} Ohms	Z_{OL} Ohms
40	4.5-j5.55	27.0-j4.40
60	2.8-j5.4	25.0-j9.5
80	1.65-j4.75	21.0-j17.0
100	1.5-j4.55	16.7-j23.0

FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

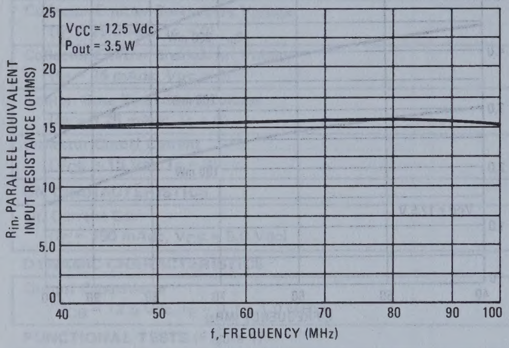


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

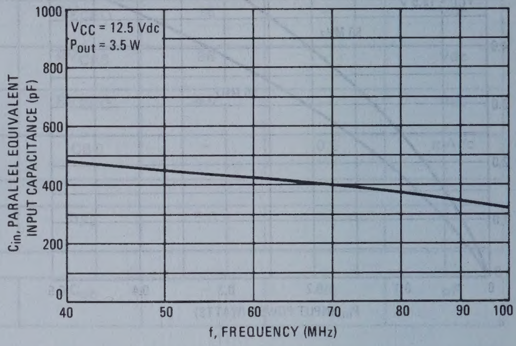


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

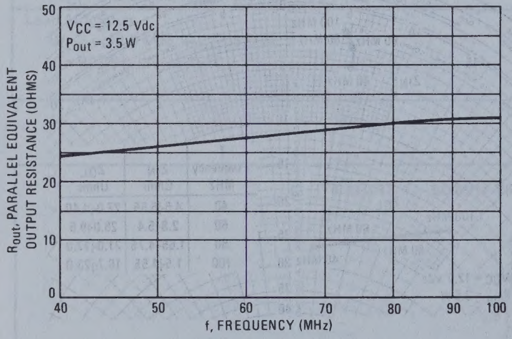
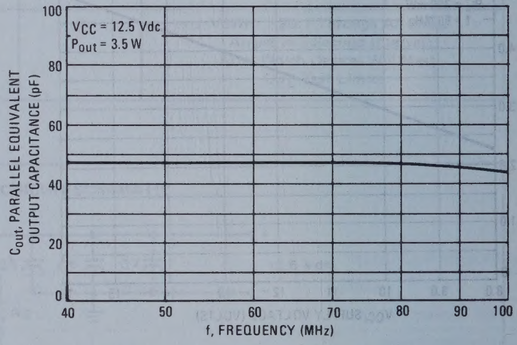


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



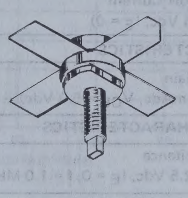
MRF232 (SILICON)

The RF Line

7.5 W – 90 MHz

RF POWER TRANSISTOR

NPN SILICON



NPN SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt, mid-band large-signal amplifier applications in industrial and commercial FM equipment operating in the 40 to 100 MHz range.

- Specified 12.5 Volt, 90 MHz Characteristics –
  Output Power = 7.5 Watts
  Minimum Gain = 9.0 dB
  Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Characterized with Parallel Equivalent Large-Signal Impedance Parameters

MAXIMUM RATINGS

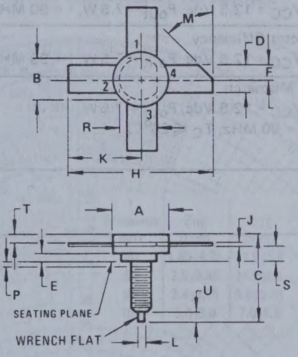
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	20 114	Watts mW/^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC
Stud Torque (2)	–	6.5	In. Lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	8.75	$^oC/W$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

(2) For repeated assembly use 5 In. Lb.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

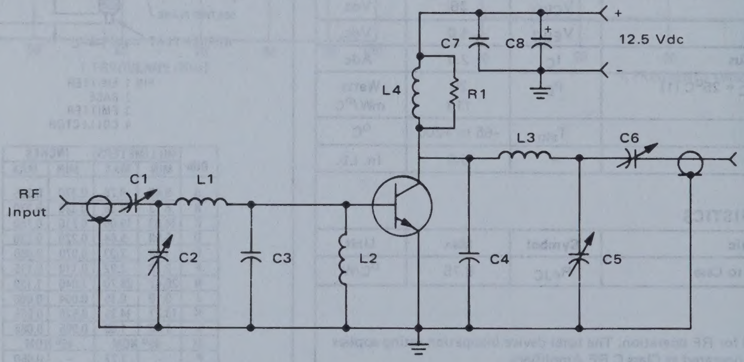
NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	18	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.5 mAdc, I_C = 0)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	—	—
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	55	pF
FUNCTIONAL TESTS (Figure 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 7.5 W, f = 90 MHz)	G_{PE}	9.0	—	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 7.5 W, f = 90 MHz)	η	55	—	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 7.5 W, f = 90 MHz, $T_C \leqslant 25^{\circ}C$)	—	VSWR $>$30:1 Through All Phase Angle in a 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits.		

FIGURE 1 — 90 MHz TEST CIRCUIT SCHEMATIC



C1,C6	5.0-80 pF, ARCO 462
C2,C5	9.0-180 pF, ARCO 463
C3,C4	100 pF UNELCO
C7	1000 pF UNELCO
C8	4.7 μF, 15 Vdc, TANTALUM

L1	3 Turns, #18 AWG, 3/8″ I.D., 3/8″ Long
L2	FERROXCUBE VK200-20-4B Ferrite Choke
L3	3 Turns, #18 AWG, 5/16″ I.D., 3/8″ Long
L4	10 Turns, #22 AWG, on R1
R1	340 Ohm, 1 W Carbon

Input/Output Connectors — Type BNC

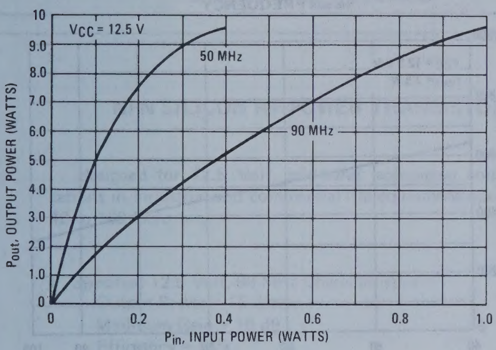


FIGURE 2 – OUTPUT POWER versus INPUT POWER

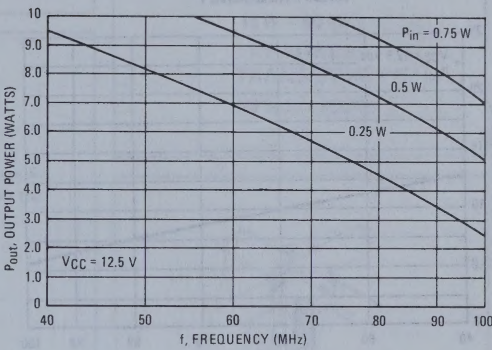


FIGURE 3 – OUTPUT POWER versus FREQUENCY

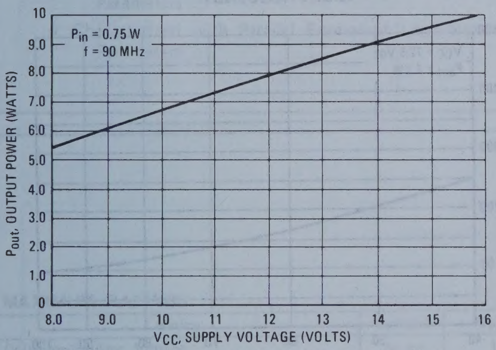


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

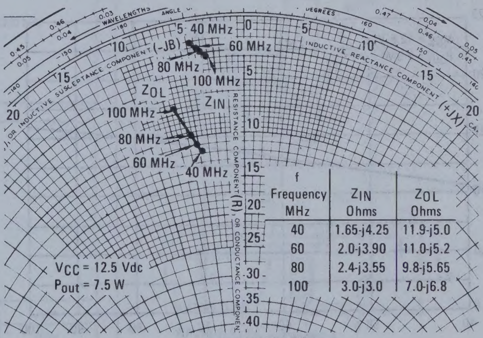


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE

f Frequency MHz	ZIN Ohms	ZOL Ohms
40	1.65-j4.25	11.9-j5.0
60	2.0-j3.90	11.0-j5.2
80	2.4-j3.55	9.8-j5.65
100	3.0-j3.0	7.0-j6.8

FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

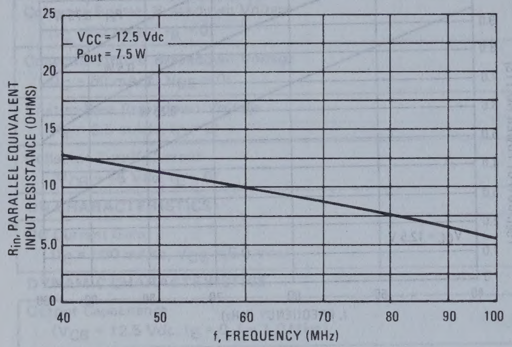


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

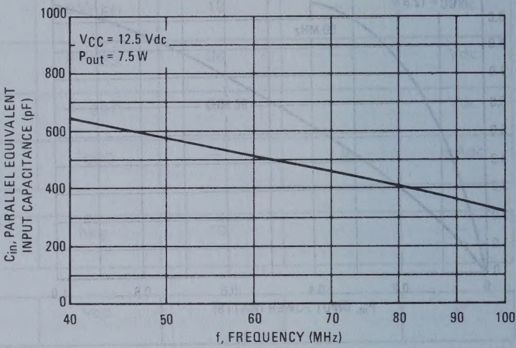


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

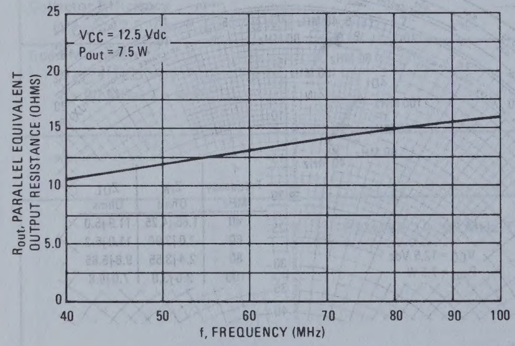
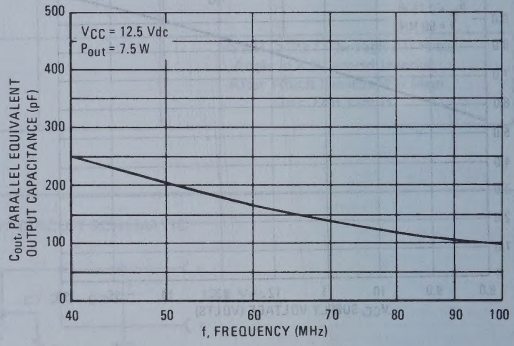


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



MRF233 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTORS

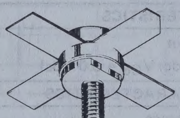
. . . designed for 12.5 Volt, mid-band large-signal amplifier applications in industrial and commercial FM equipment operating in the 40 to 100 MHz range.

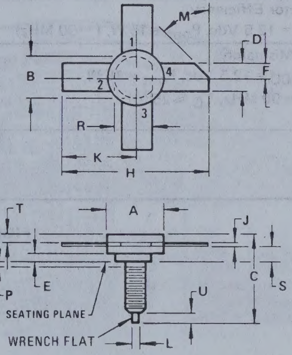
- Specified 12.5 Volt, 90 MHz Characteristics –
  Output Power = 15 Watts
  Minimum Gain = 10 dB
  Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Characterized with Parallel Equivalent Large-Signal Impedance Parameters

15 W – 90 MHz

RF POWER TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	3.5	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ (1) Derate Above 25°C	P_D –	50 285	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque (2)	–	6.5	In-lb

THERMAL CHARACTERISTICS

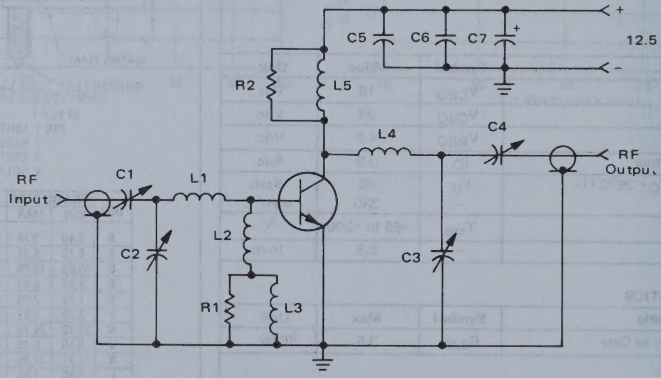
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.5	°C/W

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.
(2) For Repeated Assembly use 5 In. Lb.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	100	120	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 90 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 90 MHz)	η	55	–	–	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 15 W, f = 90 MHz, $T_C \leqslant 25°C$)	–	VSWR > 30:1 Through All Phase Angles in a 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits			

FIGURE 1 — 90 MHz TEST CIRCUIT SCHEMATIC



C1,C3	9.0-180 pF, ARCO 463
C2,C4	25-280 pF ARCO 464
C5	1000 pF UNELCO
C6	0.01 µF ERIE Disc Ceramic
C7	1.0 µF, 35 Vdc TANTALUM
L1	2 Turns, #18 AWG, 3/8" I.D., 1/4" Long
L2	0.22 µH, 9230-04 MILLER Molded Choke
L3	2.2 µH, 9230-200 MILLER Molded Choke
L4	2 Turns, #18 AWG, 3/8" I.D., 3/8" Long
L5	10 Turns, #16 AWG, Wound On R2.
R1	15 Ohm, 1/2 W, 10% Carbon
R2	68 Ohm, 1 Watt, 10% Carbon

Input/Output Connectors — Type BNC

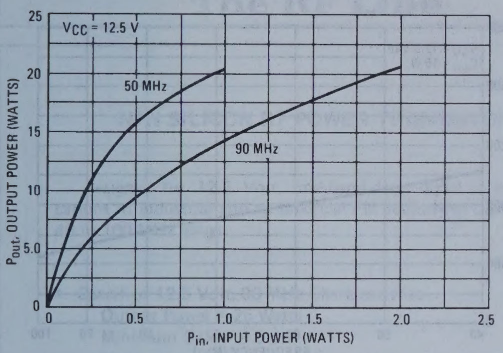


FIGURE 2 – OUTPUT POWER versus INPUT POWER

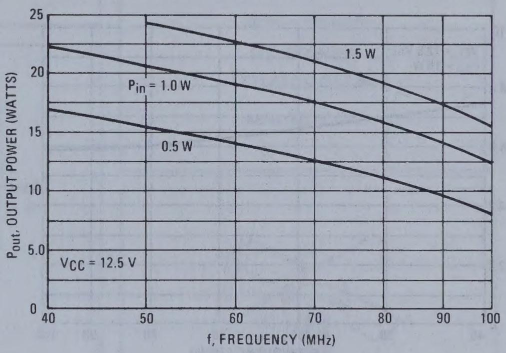


FIGURE 3 – OUTPUT POWER versus FREQUENCY

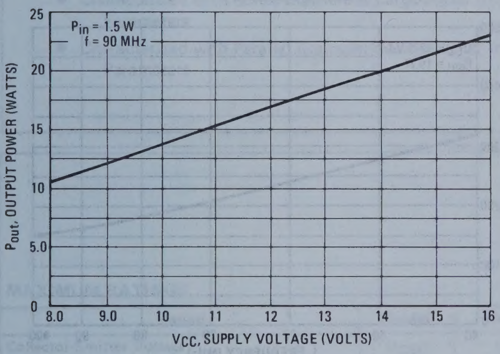


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

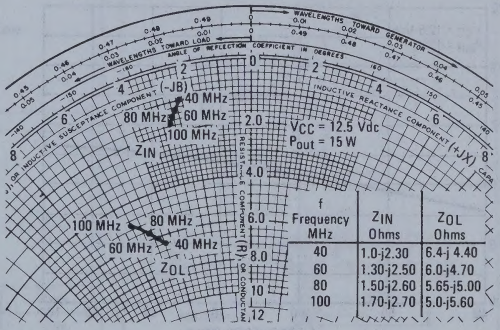


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE

f Frequency MHz	ZIN Ohms	ZOL Ohms
40	1.0-j2.30	6.4-j 4.40
60	1.30-j2.50	6.0-j4.70
80	1.50-j2.60	5.65-j5.00
100	1.70-j2.70	5.0-j5.60

FIGURE 6 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

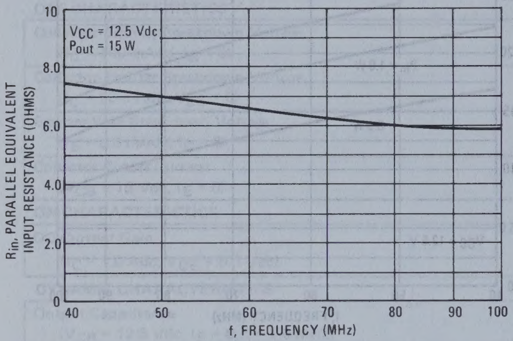


FIGURE 7 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

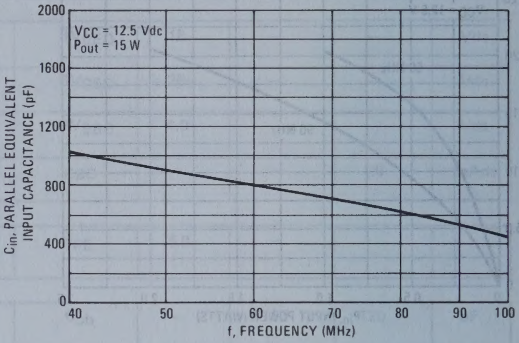


FIGURE 8 – PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

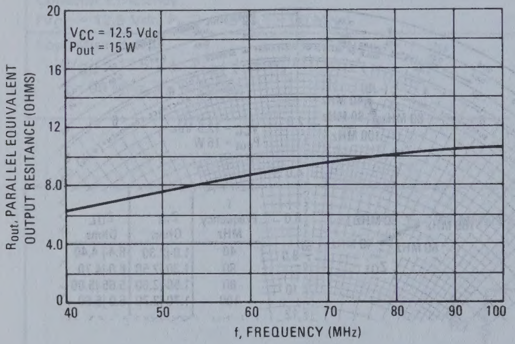
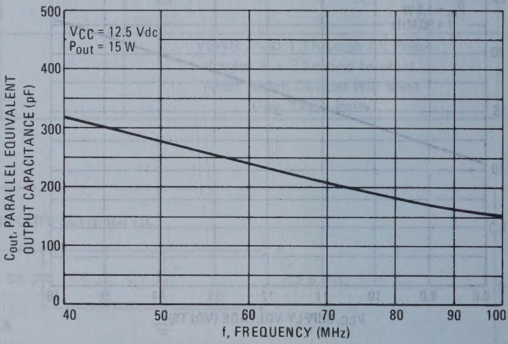


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



MRF234 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTORS

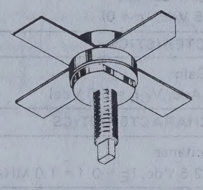
. . . designed for 12.5 Volt, mid-band large-signal amplifier applications in industrial and commercial FM equipment operating in the 40 to 100 MHz range.

- Specified 12.5 Volt, 90 MHz Characteristics –
  - Output Power = 25 Watts
  - Minimum Gain = 9.5 dB
  - Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR.
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Characterized with Parallel Equivalent Large-Signal Impedance Parameters

25 W – 90 MHz

RF POWER
TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

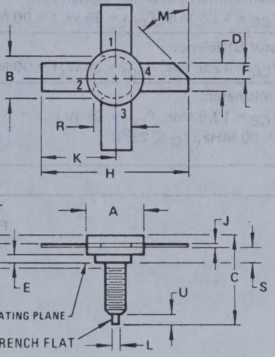
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	4.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	70 400	Watts $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC
Stud Torque (2)	–	6.5	In. Lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	$^oC/W$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

(2) For repeated assembly use 5 In. Lb.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

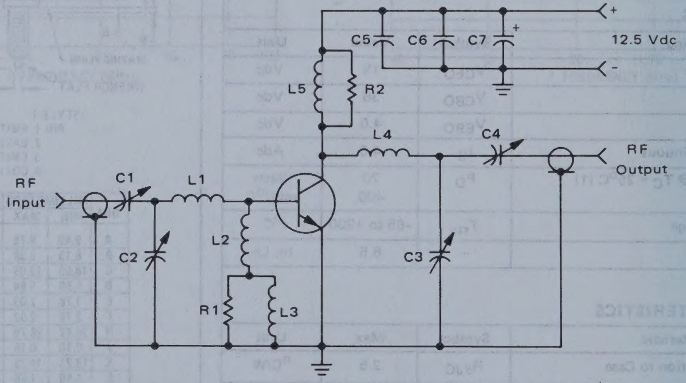
NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	100	120	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 90 MHz)	G_{PE}	9.5	–	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 90 MHz)	η	55	–	–	%
Load Mismatch (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 90 MHz, $T_C \leqslant$ 25°C	–	VSWR >30:1 Through All Phase Angles in a 3 Second Interval After Which Devices Will Meet G_{PE} Test Limits.			

FIGURE 1 — 90 MHz TEST CIRCUIT SCHEMATIC



C1,C4	5.0-80 pF, ARCO 462
C2,C3	25-280 pF, ARCO 464
C5	1000 pF UNELCO
C6	0.047 μF, ERIE disc ceramic
C7	10 μF, 15 Vdc TANTALUM
L1	1 Turn, #16 AWG, 3/8″ I.D., 1/8″ Long
L2	0.22 μH, 9230-04 MILLER Molded Choke
L3	22 μH, 9230-52 MILLER Molded Choke
L4	2 Turns, #14 AWG, 3/8″ I.D., 1/4″ Long
L5	10 Turns, #18 AWG, 1/4″ I.D., wound on R2
R1	15 Ohms, 1/2 W, 10%
R2	47 Ohm, 1 W Carbon

Input/Output Connector — Type BNC

FIGURE 2 – OUTPUT POWER versus INPUT POWER

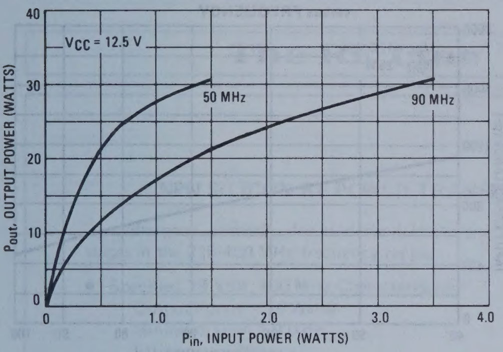


FIGURE 3 – OUTPUT POWER versus FREQUENCY

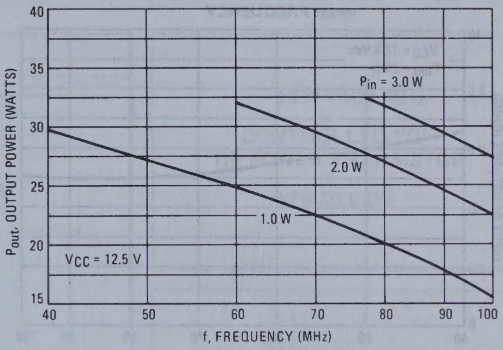


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

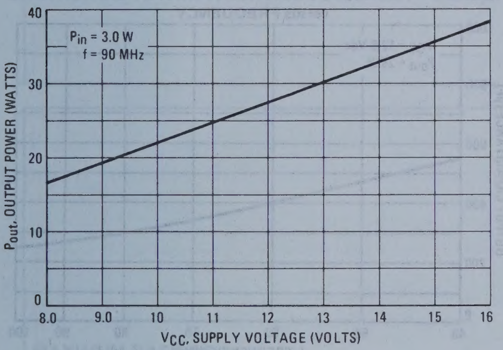
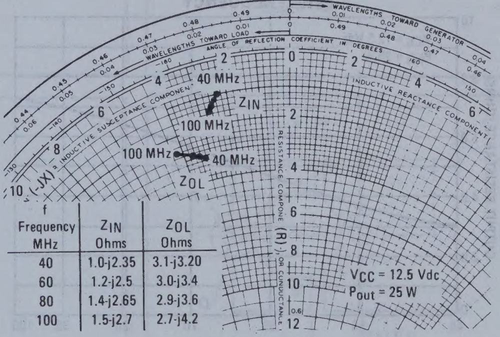


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



f Frequency MHz	ZIN Ohms	ZOL Ohms
40	1.0-j2.35	3.1-j3.20
60	1.2-j2.5	3.0-j3.4
80	1.4-j2.65	2.9-j3.6
100	1.5-j2.7	2.7-j4.2

FIGURE 6 — PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

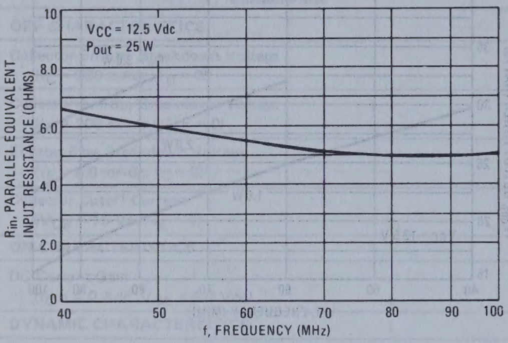


FIGURE 7 — PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

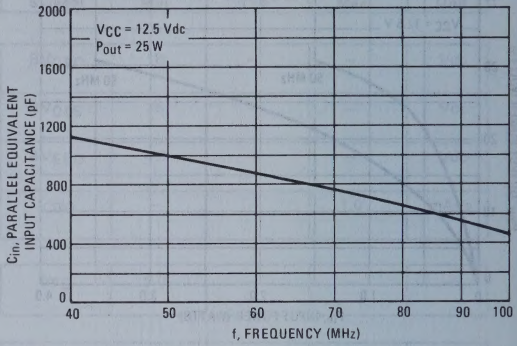


FIGURE 8 — PARALLEL EQUIVALENT OUTPUT RESISTANCE versus FREQUENCY

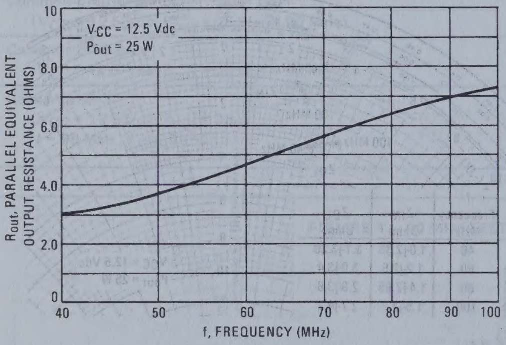
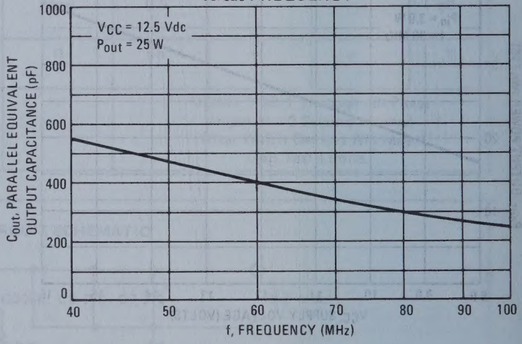


FIGURE 9 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



MRF304 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

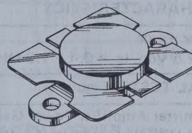
. . . designed primarily for wideband large-signal driver amplifier stages in the 225-400 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics –
  Output Power = 10 Watts
  Minimum Gain = 9.0 dB
  Efficiency = 60%
- Built-In Matching Network for Broadband Operation
- 100% tested for Load Mismatch at all Phase Angles with 30:1 VSWR

10 W - 400 MHz

**CONTROLLED "Q"
RF POWER TRANSISTOR**

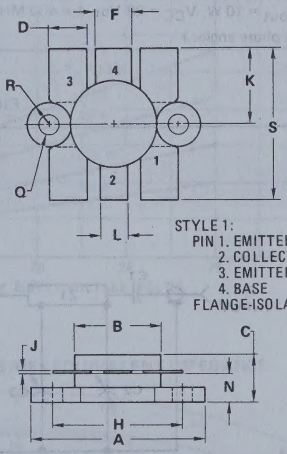
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ (1) Derate above 25°C	P_D	30 171	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

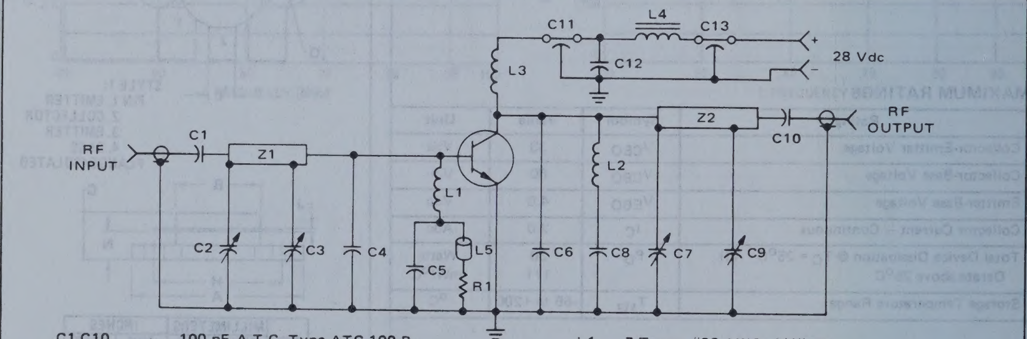
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.46 TYP		0.215 TYP	
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

CASE 278-03

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	33	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	 10 10	 – –	 100 –	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	21	25	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 10 W, f = 400 MHz)	G_{PE}	9.0	–	–	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 10 W, f = 400 MHz)	η	60	–	–	%
Electrical Ruggedness (P_{out} = 10 W, V_{CC} = 28 Vdc, f = 400 MHz, VSWR 30:1, all phase angles.)	–	No Degradation in P_{out}			–

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1,C10	100 pF A.T.C. Type ATC-100 B
C2,C3,C7,C9	1.0-20 pF, JOHANSON Type 3906
C4	2, 10 pF UNDERWOOD (UNELCO) one on each side of the base lead
C5	100 pF UNDERWOOD (UNELCO)
C6	2, 15 pF UNDERWOOD (UNELCO) one on each side of the collector lead
C8	0.1 µF, 100 V Disc Ceramic
C11,C13	680 pF ALLEN BRADLEY Feedthru
C12	1.0 µF, 35 V TANTALUM
R1	2.7 Ohms, 1/2 W, 10%

L1	7 Turns, #20 AWG, 1/4" ID
L2	1 Turn, 1/8" ID, lead of C8
L3	7 Turns, #20 AWG, 1/4" ID
L4	FERRITE Choke, FERROXCUBE VK200-20-4B
L5	FERRITE Bead on lead of R1, FERROXCUBE 56-590-65-3B
Z1	MICROSTRIPLINE 0.2" W x 1.6" L, C2 Mounted 0.3 Inches From Start C3 Mounted 1.1 Inches From Start
Z2	MICROSTRIPLINE, 0.300" W x 1.70" L C7 Mounted at Collector C9 Mounted 0.4" From End

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062"

Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

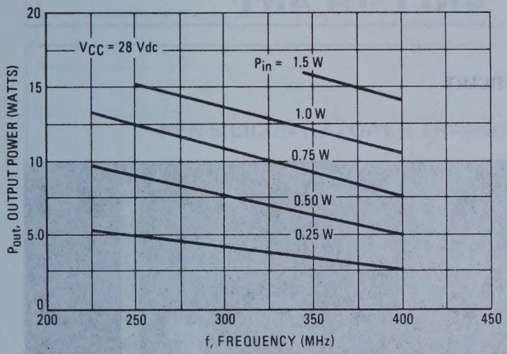


FIGURE 3 – OUTPUT POWER versus INPUT POWER

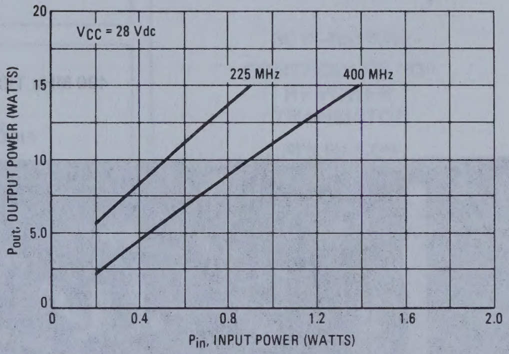


FIGURE 4 – POWER GAIN versus FREQUENCY

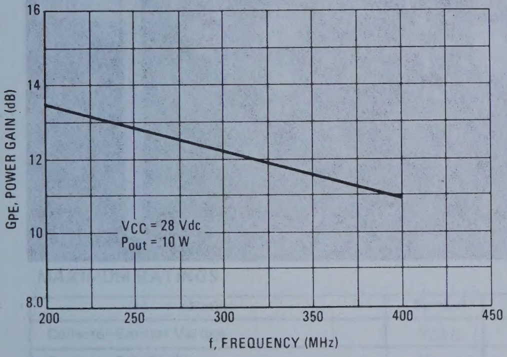


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE – 400 MHz

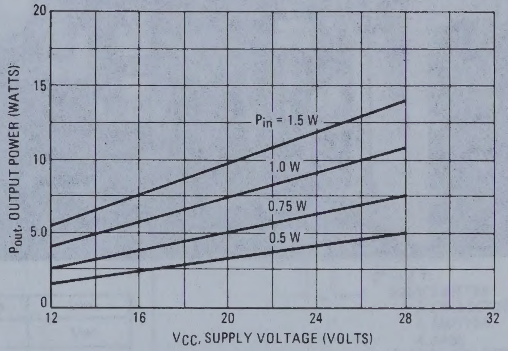


FIGURE 6 – OUTPUT POWER versus SUPPLY VOLTAGE – 225 MHz

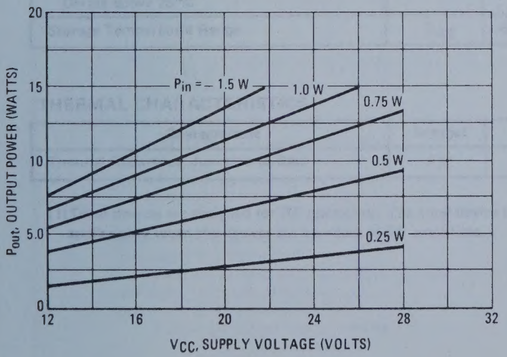
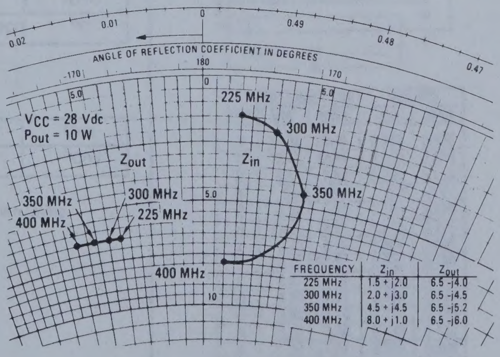


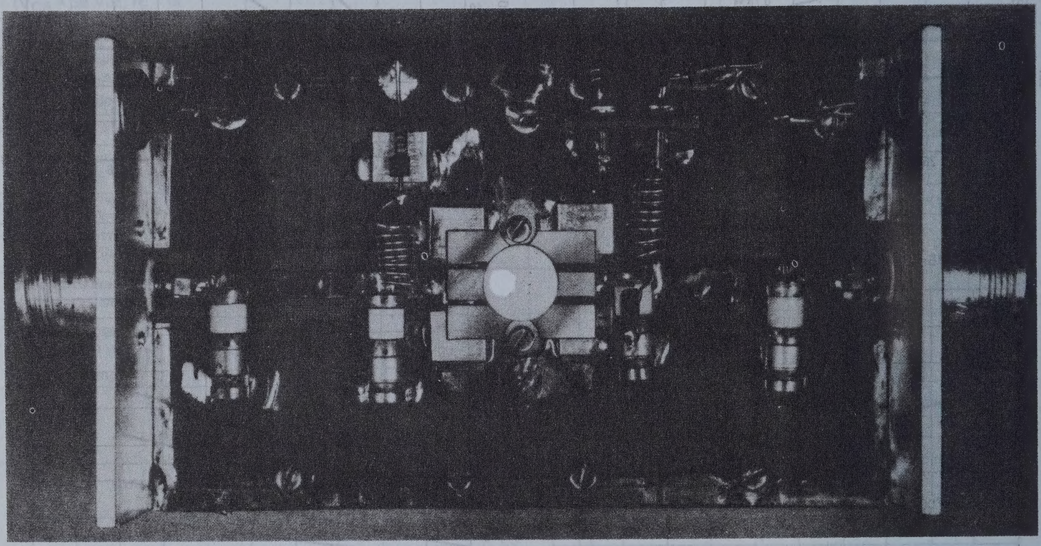
FIGURE 7 – SERIES EQUIVALENT IMPEDANCE



FREQUENCY	Z_{in}	Z_{out}
225 MHz	1.5 + j2.0	6.5 -j4.0
300 MHz	2.0 + j3.0	6.5 -j4.5
350 MHz	4.5 + j4.5	6.5 -j5.2
400 MHz	8.0 + j1.0	6.5 -j6.0

400 MHz TEST CIRCUIT

FIGURE 8

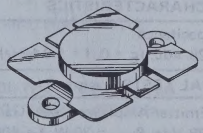


MRF305 (SILICON)

The RF Line

30 W-400 MHz
CONTROLLED "Q"
RF POWER
TRANSISTOR

NPN SILICON



NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for wideband large-signal driver and output amplifier stages in the 225-400 MHz frequency range.

- Specified 28 Volt, 400 MHz Characteristics –
  Output Power = 30 Watt
  Minimum Gain = 8.0 dB
  Efficiency = 55% (Min)
- Built-In Matching Network for Broadband Operation
- 100% Tested for Load Mismatch at all Phase Angles with 30:1 VSWR

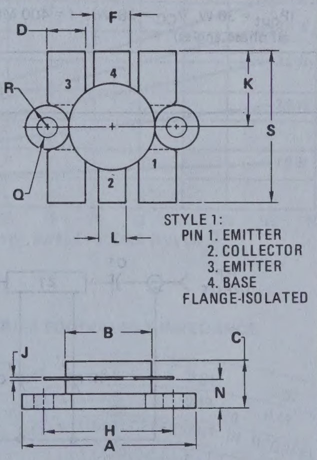
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	70 0.4	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.5	$^oC/W$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

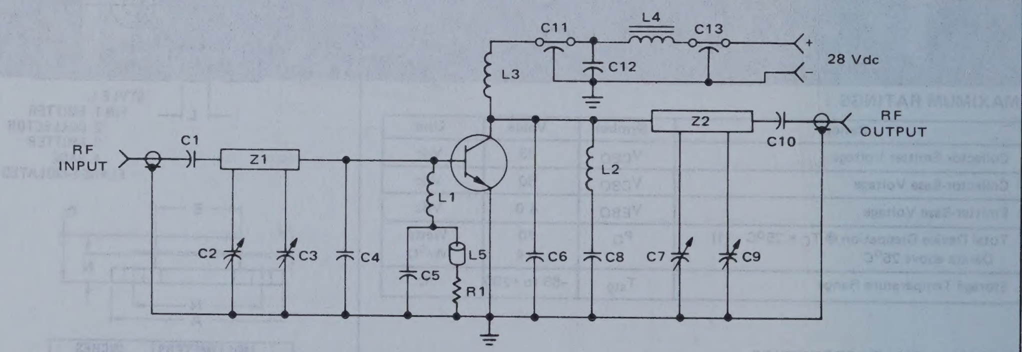
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.46 TYP		0.215 TYP	
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

CASE 278-03

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	33	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 3.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		10	–	100	
(I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)		10	–	–	
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	40	45	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 400 MHz)	G_{PE}	8.0	–	–	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 30 W, f = 400 MHz)	η	55	–	–	%
Electrical Ruggedness (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz, VSWR 30:1, all phase angles)	–	No Degradation in P_{out}			–

FIGURE 1 — 400 MHz TEST CIRCUIT SCHEMATIC



C1,C10	0.018 µF VITRAMON Chip Capacitor
C2,C3,C7,C9	1.0-20 pF JOHANSON Type 3906
C4	2, 10 pF UNDERWOOD (UNELCO) one each side of the Base Lead
C5	100 pF UNDERWOOD (UNELCO)
C6	2, 20 pF UNDERWOOD (UNELCO) one each side of the Collector Lead
C8	0.1 µF, 100 V Disc Ceramic
C11,13	680 pF ALLEN BRADLEY Feedthru
C12	1.0 µF, 35 V TANTALUM
R1	2.7 Ohm, 1/2 Watt, 10%
L1	3 Turns, #24 AWG, 1/8" ID
L2	2 Turns, Lead of C8, 1/8" ID

L3	5 Turns, #20 AWG, 1/4" ID
L4	FERRITE Choke, FERROXCUBE VK200-20-4B
L5	FERRITE Bead on Lead of R1, FERROXCUBE 56-590-65-3B
Z1	Microstrip Line, 0.2" W x 1.7" L C2 Mounted 0.3" from Start C3 Mounted 0.9" from Start
Z2	Microstrip Line, 0.3" W x 1.5" L C7 Mounted 0.8" from End C9 Mounted 0.2" from End

Board — Glass Teflon ϵ_R = 2.56, t = 0.062 in.

Input Output Connectors Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

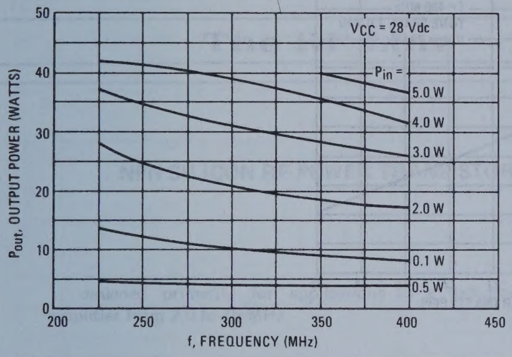


FIGURE 3 – OUTPUT POWER versus INPUT POWER

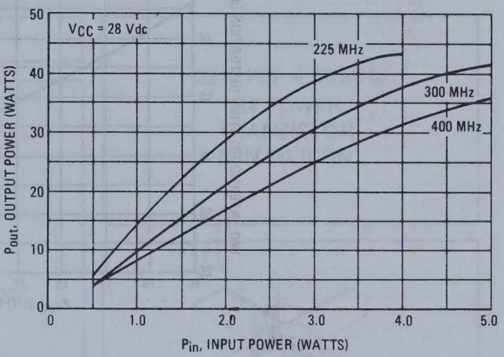


FIGURE 4 – POWER GAIN versus FREQUENCY

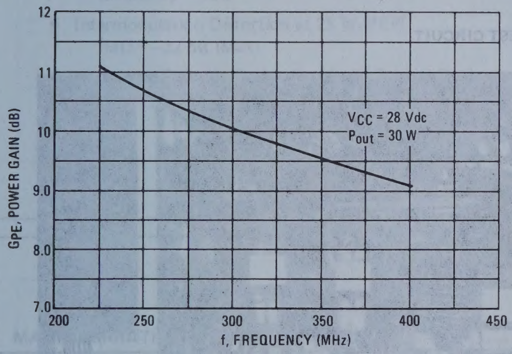


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE – 400 MHz

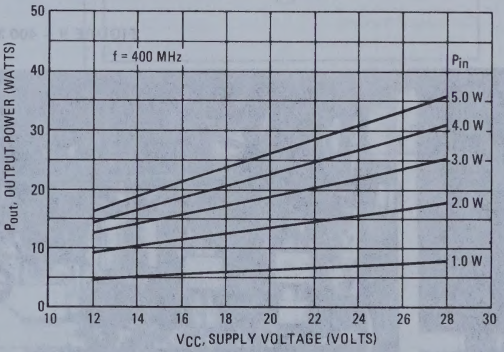


FIGURE 6 – OUTPUT POWER versus SUPPLY VOLTAGE – 225 MHz

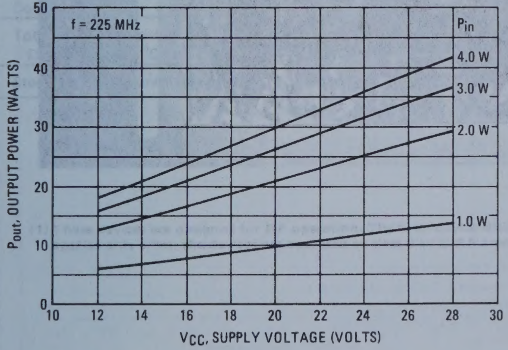
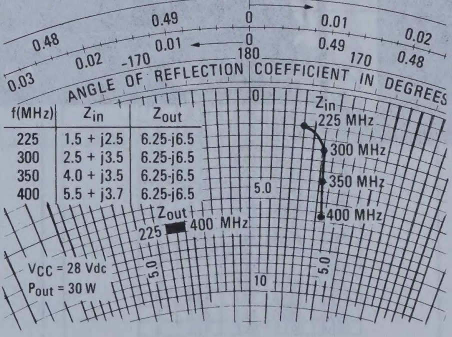


FIGURE 7 – SERIES EQUIVALENT IMPEDANCE



f(MHz)	Z_{in}	Z_{out}
225	1.5 + j2.5	6.25-j6.5
300	2.5 + j3.5	6.25-j6.5
350	4.0 + j3.5	6.25-j6.5
400	5.5 + j3.7	6.25-j6.5

FIGURE 8 – INTERMODULATION DISTORTION versus OUTPUT POWER (PEP)

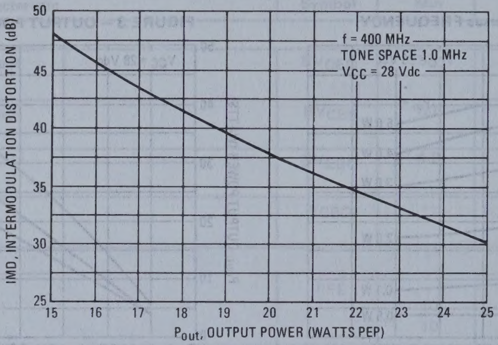
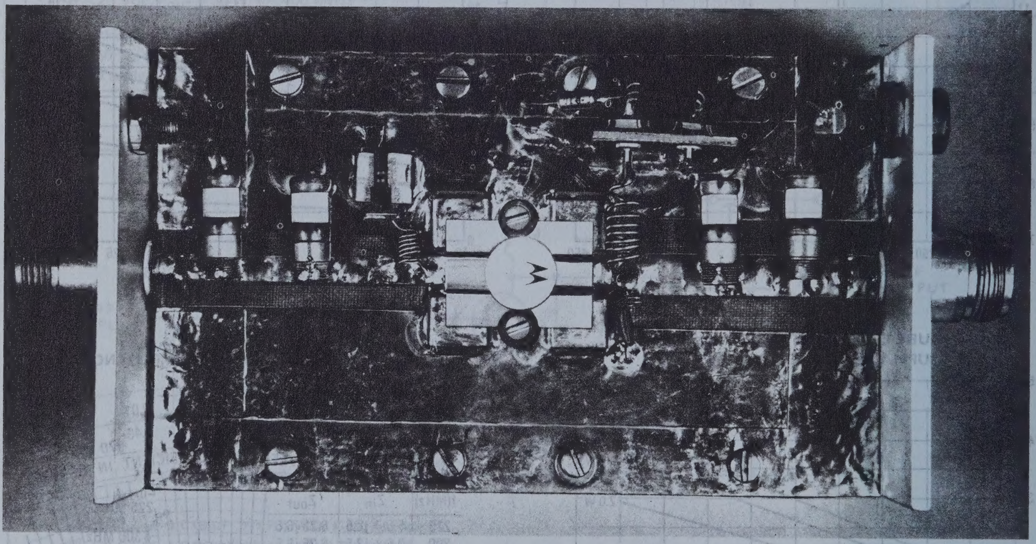


FIGURE 9 – 400 MHz TEST CIRCUIT



MRF401 (SILICON)

The RF Line

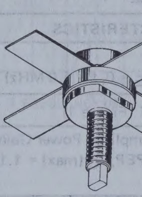
NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for applications as a high-power linear amplifier from 2.0 to 75 MHz.

- Specified 28 Volt, 30 MHz Characteristics –
  Output Power = 25 W (PEP)
  Minimum Gain = 13 dB
  Efficiency = 40%
- Intermodulation Distortion at 25 W (PEP)
  IMD = -32 dB (Max)
- Isothermal-Resistor Design Results in Rugged Device

25 W PEP – 30 MHz

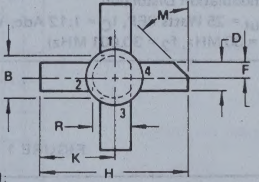
RF POWER TRANSISTOR NPN SILICON



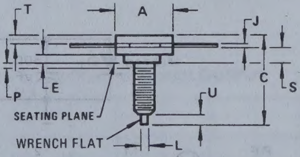
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	3.3	Adc
Total Device Dissipation @ T_C = 25°C(1) Derate above 25°C	P_D	50 28.6	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

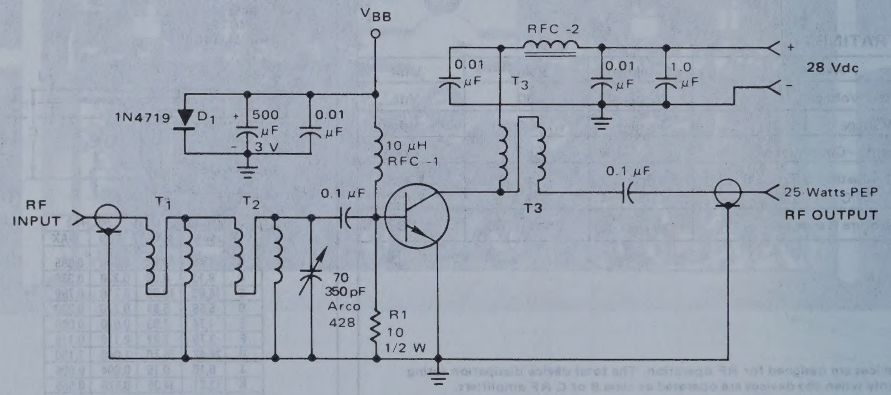
NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	20	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	65	85	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 25 Watts PEP, I_C (max) = 1.12 Adc, V_{CC} = 28 Vdc, f = 30 MHz)	G_{PE}	13	–	–	dB
Collector Efficiency (P_{out} = 25 Watts PEP, I_C (max) = 1.12 Adc, V_{CC} = 28 Vdc, f = 30 MHz)	η	40	–	–	%
Intermodulation Distortion (P_{out} = 25 Watts PEP, I_C = 1.12 Adc, V_{CC} = 28 Vdc, f_1 = 30 MHz, f_2 = 30.001 MHz)	IM	–	–	-32	dB

FIGURE 1 — 25 WATT, 2-30 MHz BROADBAND AMPLIFIER TEST CIRCUIT



V_{BB}
RFC -2
0.01 µF
T_3
0.01 µF
1.0 µF
+
28 Vdc
-
1N4719
D_1
+
500 µF
-
3 V
0.01 µF
10 µH
RFC -1
0.1 µF
0.1 µF
25 Watts PEP
RF OUTPUT
RF INPUT
T_1
T_2
70
350 pF
Arco
428
R1
10
1/2 W
T3

T_1, T_3 4:1 6 Turns of 2 Twisted Pairs of =26 AWG Enameled Wire (6 Crest Per Inch) Wound on Stackpole 57 9322 =11 Toroid.

T_2 4:1 4 Turns of 4 Twisted Pairs of =26 AWG Enameled Wire (6 Crest Per Inch) Wound on Stackpole 57 9322 =11 Toroid.

RFC -2 Ferroxcube VK200 19/4B Ferrite Choke

NOTE: Adjust V_{BB} for I_C = 20 mAdc with no RF drive present.

FIGURE 2 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

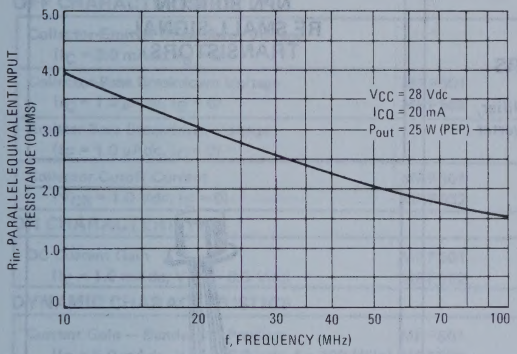


FIGURE 3 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

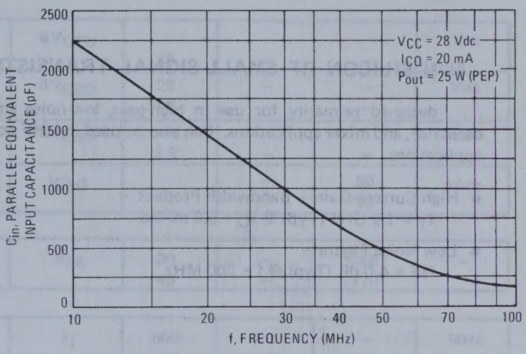


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

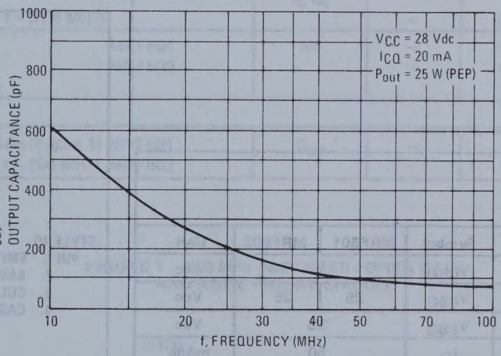


FIGURE 5 – POWER GAIN versus FREQUENCY

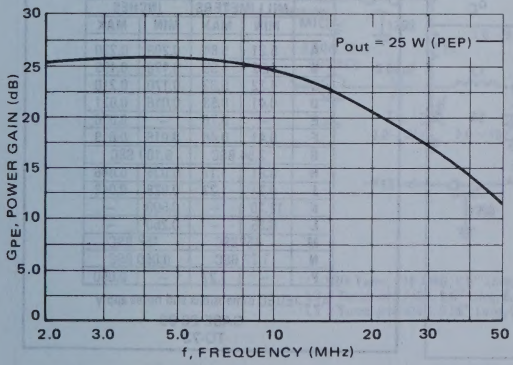
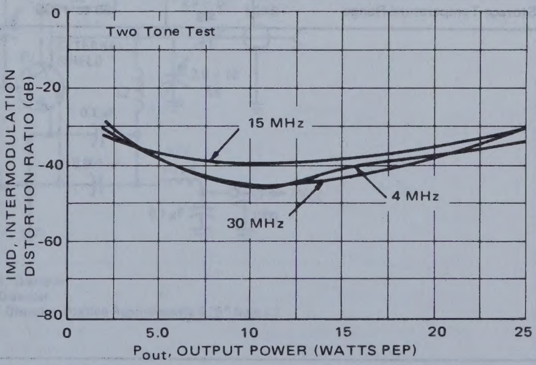


FIGURE 6 – IMD versus POWER OUTPUT



MRF501 (SILICON)
MRF502

The RF Line

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

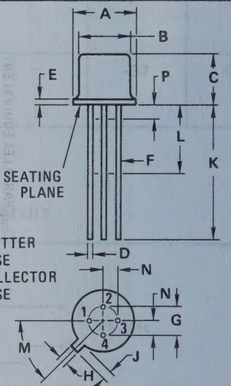
. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

- High Current-Gain – Bandwidth Product –
  f_T = 1.2 GHz (Typ) @ I_C = 5.0 mAdc
- Low Noise Figure –
  NF = 4.0 dB (Typ) @ f = 200 MHz

MAXIMUM RATINGS

Rating	Symbol	MRF501	MRF502	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CBO}	25	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14		mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

NPN SILICON
RF SMALL-SIGNAL
TRANSISTORS



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

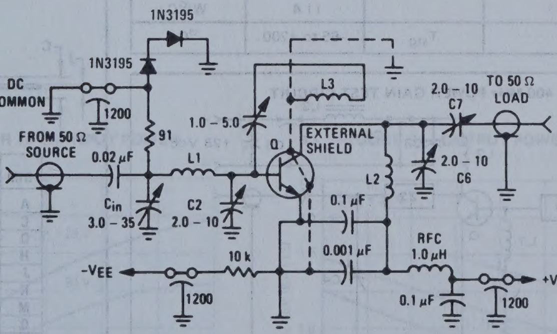
ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)		BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	MRF501 MRF502	BV_{CBO}	25 35	– –	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)		BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 1.0 Vdc, I_E = 0)	MRF501 MRF502	I_{CBO}	– –	– –	50 20	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	MRF501 MRF502	h_{FE}	30 40	– –	250 170	–
DYNAMIC CHARACTERISTICS						
Current Gain – Bandwdith Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	MRF501 MRF502	f_T	600 800	1000 1200	– –	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)		C_{cb}	–	0.6	–	pF
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.8 MHz)		$r_b'C_c$	–	8.0	–	ps
Noise Figure (Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	MRF501 MRF502	NF	– –	4.5 4.0	– –	dB
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CC} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	MRF501 MRF502	G_{pe}	– –	15 17	– –	dB

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT


1N3195
1N3195
DC COMMON
1200
FROM 50 Ω SOURCE
0.02 μF
91
L1
Cin
3.0 – 35
C2
2.0 – 10
1.0 – 5.0
Q
L3
EXTERNAL SHIELD
2.0 – 10
C7
TO 50 Ω LOAD
2.0 – 10
C6
L2
0.1 μF
0.001 μF
RFC
1.0 μH
-VEE
10 k
1200
0.1 μF
1200
+VCC

L1 1 3/4 Turns, #18 AWG, 0.5" Long, 0.5" Diameter
L2 2 Turns, #16 AWG, 0.5" Long, 0.5" Diameter
L3 2 Turns, #18 AWG, 0.25" Long, 0.5" Diameter, Position Approximately 0.25" from L2

The RF Line

NPN SILICON RF POWER TRANSISTOR

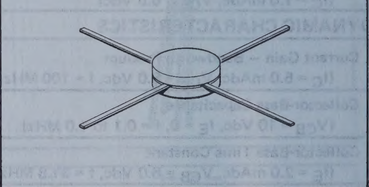
. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver or predriver stages in VHF and UHF applications.

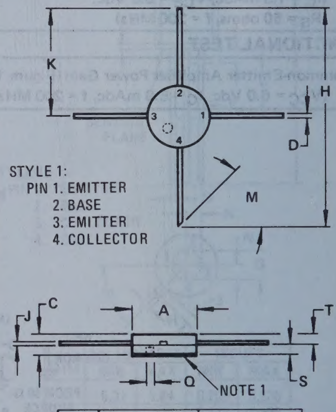
- 2N3866 – Packaged for Stripline Designs
- High Power Gain @ 400 MHz
  G_{PE} = 10 dB @ V_{CC} = 28 Vdc

1 W – 400 MHz

RF POWER
TRANSISTOR

NPN SILICON





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.99	7.37	0.275	0.290
C	2.79	3.30	0.110	0.130
D	0.64	0.89	0.025	0.035
H	37.73	36.27	1.328	1.428
J	0.33	0.43	0.013	0.017
K	16.87	18.14	0.664	0.714
M	40°	50°	40°	50°
Q	0.69	0.84	0.027	0.033
S	1.40	1.65	0.055	0.065
T	1.40	1.65	0.055	0.065

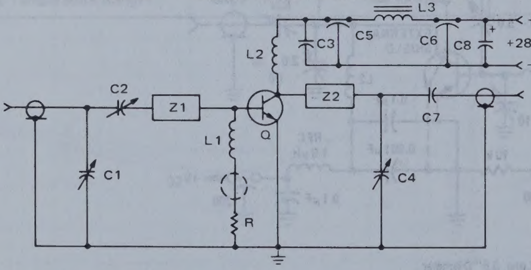
NOTE:
1. BOTTOM SIDE METALLIZED PLATED

CASE 207A-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	55	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current – Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate Above 25^oC	P_D	2.0 11.4	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – 400 MHz POWER GAIN TEST CIRCUIT



C1, C2, C4	1.0-20 pF (Johanson 9063)	R	4.7 Ohms, 1/4 W
C3	0.1 µF	Z1	2.0″ x 0.1″ Strip
C5, C6	680 pF Feedthru	Z2	5.3″ x 0.1″ Strip
C7	150 pF Chip	L1, L2	5 T AWG #20, 1/4″ I.D.
C8	1.0 µF Tantalum	L3	FERROXCUBE VK200
		Q	MRF509

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	BV_{CEO}	30	–	–	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $R_{BE} = 10\ \Omega$)	BV_{CER}	55	–	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mAdc, $I_E = 0$)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current ($V_{CE} = 28$ Vdc, $I_B = 0$)	I_{CEO}	–	–	0.02	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	30	–	200	–
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, f = 200 MHz)	f_T	500	1000	–	MHz
Output Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	–	2.2	3.0	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain ($P_{out} = 1.0$ W, $V_{CC} = 28$ Vdc, f = 400 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency ($P_{out} = 1.0$ W, $V_{CC} = 28$ Vdc, f = 400 MHz)	η	40	–	–	%

FIGURE 2 – OUTPUT POWER versus INPUT POWER

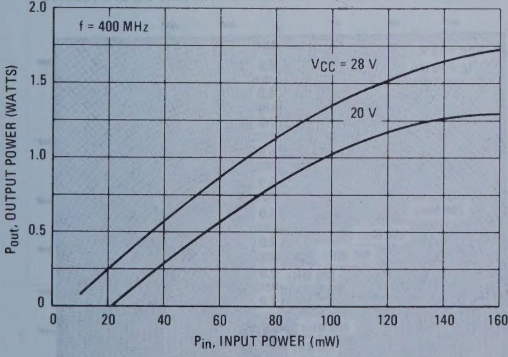


FIGURE 3 – OUTPUT POWER versus FREQUENCY

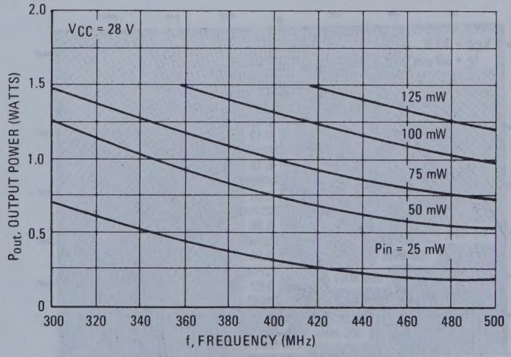


FIGURE 4 – CURRENT-GAIN-BANDWIDTH PRODUCT

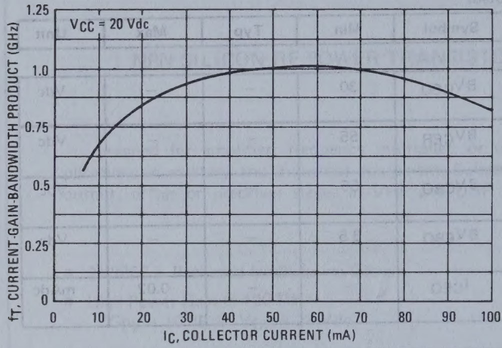
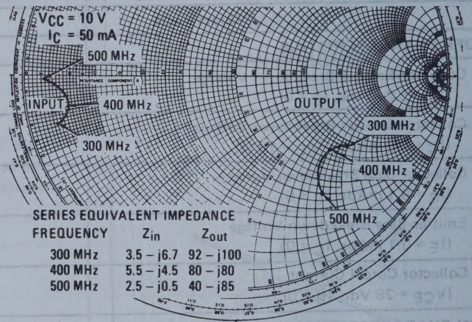


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



SERIES EQUIVALENT IMPEDANCE

FREQUENCY	Z_{in}	Z_{out}
300 MHz	3.5 – j6.7	92 – j100
400 MHz	5.5 – j4.5	80 – j80
500 MHz	2.5 – j0.5	40 – j85

FIGURE 6 – S11, INPUT REFLECTION COEFFICIENT

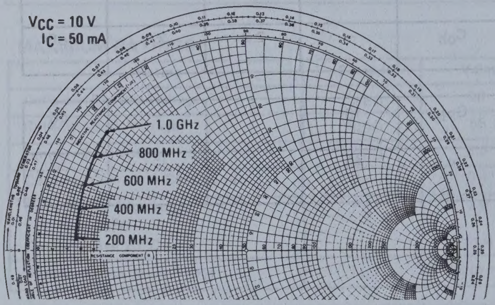


FIGURE 7 – S22, OUTPUT REFLECTION COEFFICIENT

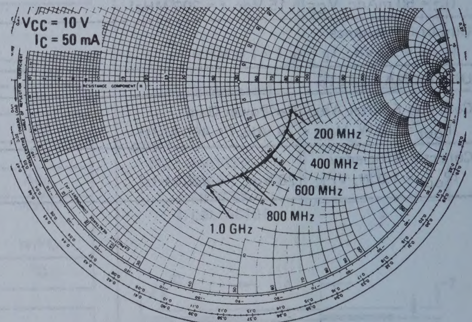


FIGURE 8 – S12, REVERSE TRANSMISSION COEFFICIENT

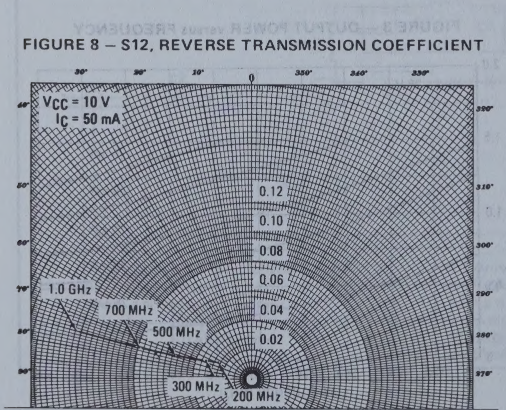


FIGURE 9 – S21, FORWARD TRANSMISSION COEFFICIENT

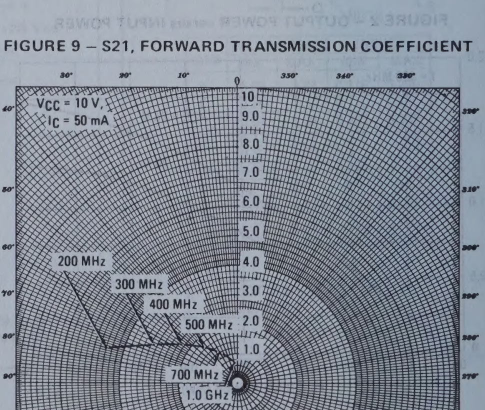
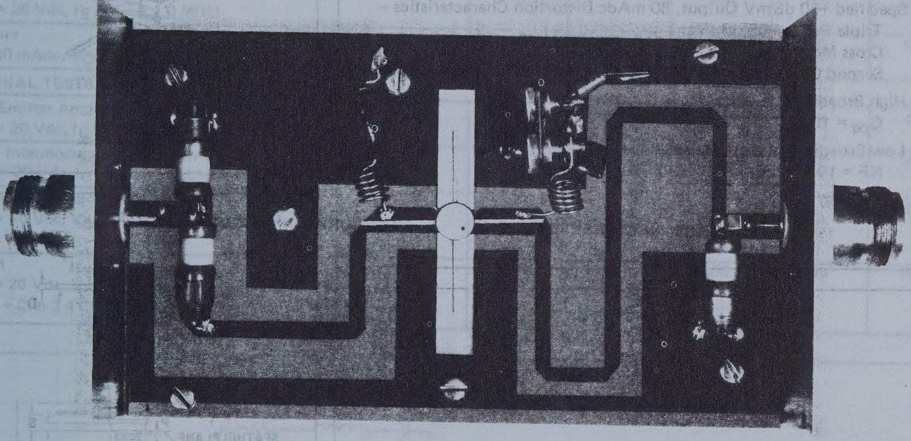


FIGURE 10 – 400 MHz TEST CIRCUIT



MRF511 (SILICON)

The RF Line

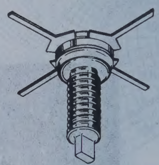
NPN SILICON HIGH FREQUENCY TRANSISTOR

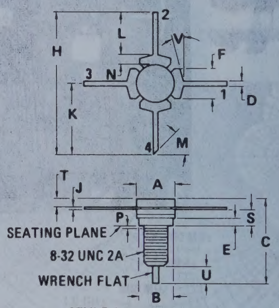
. . . designed specifically for broadband applications requiring low distortion characteristics and noise figure. Specified for use in CATV applications.

- Specified +50 dBmV Output, 80 mAdc Distortion Characteristics –
  Triple Beat = -65 dB (Max)
  Cross Modulation = -57 dB (Max)
  Second Order = -50 dB (Max)
- High Broadband Power Gain –
  G_{pe} = 10 dB (Min) @ f = 250 MHz
- Low Broadband Noise Figure –
  NF = 10 dB (Max) @ f = 200 MHz

HIGH FREQUENCY TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
B	6.25	6.45	0.246	0.254
C	15.49	16.51	0.610	0.650
D	0.64	0.89	0.025	0.035
E	1.40	1.65	0.055	0.065
F	5.59	5.84	0.220	0.230
H	26.67	27.18	1.050	1.070
J	0.10	0.15	0.004	0.006
K	13.34	13.59	0.525	0.535
L	8.26	8.51	0.325	0.335
M	40°	50°	40°	50°
N	1.40	1.65	0.055	0.065
P	–	1.27	–	0.050
S	3.00	3.25	0.118	0.128
T	1.40	1.65	0.055	0.065
U	2.92	3.68	0.115	0.145
V	10°	20°	10°	20°

CASE 144D-04

MAXIMUM RATINGS

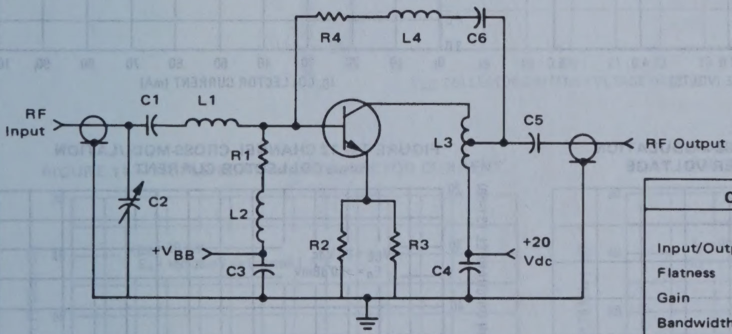
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CBO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current – Continuous	I_C	250	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque(1)	–	6.5	In. Lb.

(1) For Repeated Assembly use 5 In. Lb.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	25	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	35	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 80 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	50	200	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	0.2	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 80 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	1.5	2.1	–	GHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	3.2	4.5	pF
Noise Figure (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	NF	–	7.3	10	dB
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CE} = 20 Vdc, I_C = 80 mAdc, f = 250 MHz)	G_{pe}	10	11	–	dB
2nd Order Intermodulation Distortion (V_{CE} = 20 Vdc, I_C = 80 mAdc, Chn 2 + Chn 13 = 266.5 MHz)	IMD	–	-55	-50	dB
Cross-Modulation Distortion					dB
(V_{CE} = 20 Vdc, V_{out} = +50 dBmV, I_C = 80 mAdc) Chn 13	12 Chn XMD	–	-59	-57	
Chn R	30 Chn XMD	–	-46	–	
Triple Beat (V_{CE} = 20 Vdc, I_C = 80 mAdc, V_{out} = +50 dBmV, Chn 2 + Chn 3 + Chn E = 261.75 MHz)	TB	–	-68	-65	dB

FIGURE 1 — 40 to 330 MHz BROADBAND TEST CIRCUIT SCHEMATIC



CIRCUIT PERFORMANCE	Min	Typ
Input/Output Return Loss	–	18 dB
Flatness	–	+0.3 dB
Gain	10 dB	
Bandwidth	–	40-300 MHz

C1,C3,C4,C5,C6	0.002 μF Ceramic Disc
C2	0.35-3.5 pF JOHANSON 4702
L1	2 Turns, #20 AWG, 1/8" I.D., 0.2 " Long
L2	5 μH, Ferrite Choke, MILLER
L3	18 Turns, #24 AWG Enamelled, on Ferrite Torrid Core FERROXCUBE 1041TO60-4C7
L4	5 Turns, #20 AWG, 3/16" I.D., 0.35" Long

R1	4.7 kΩ, 1/4W, 10%
R2	27 Ω, 1W, 10%
R3	27 Ω, 1W,10%
R4	300 Ω, 1/4W, 10%.

Input/Output Connectors – Type F

Z_o – 75 Ohms

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

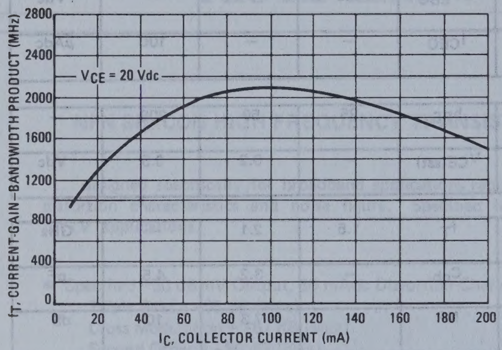


FIGURE 3 – OUTPUT CAPACITANCE

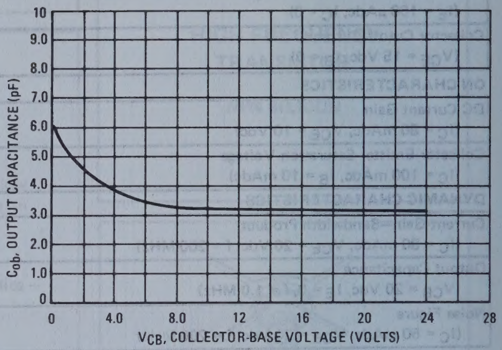


FIGURE 4 – INPUT CAPACITANCE

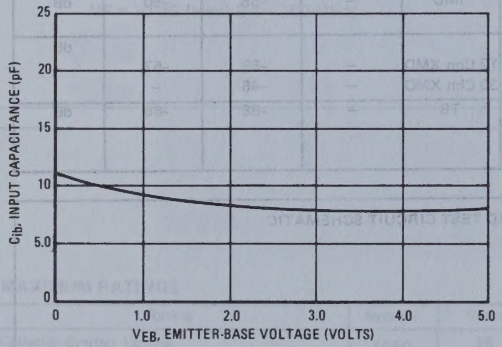


FIGURE 5 – BROADBAND NOISE FIGURE

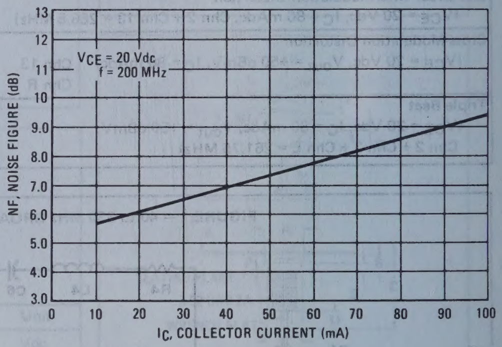


FIGURE 6 – 12 CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE

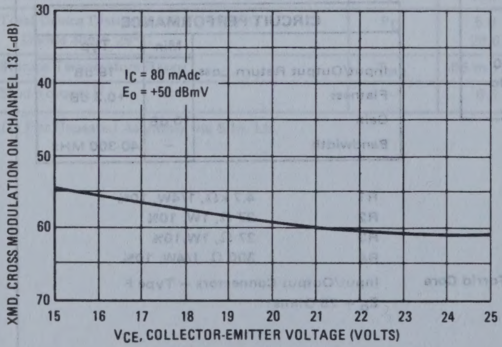


FIGURE 7 – 12 CHANNEL CROSS-MODULATION versus COLLECTOR CURRENT

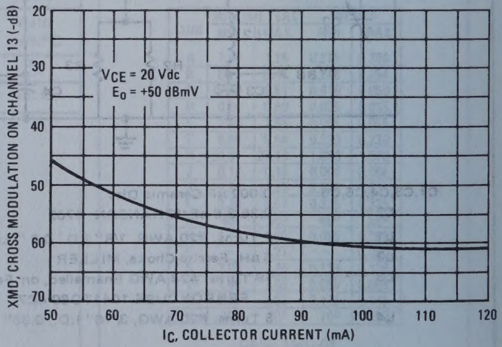


FIGURE 8 – 30 CHANNEL CROSS-MODULATION ON CHANNEL R

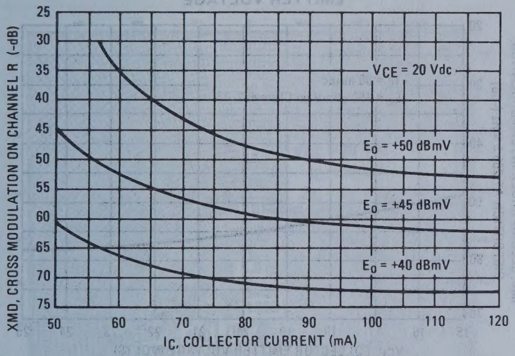


FIGURE 9 – 30 CHANNEL CROSS-MODULATION ON CHANNEL 2,13,R

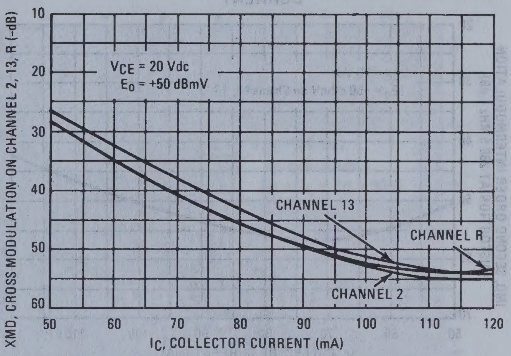


FIGURE 10 – 30-CHANNEL CROSS-MODULATION versus COLLECTOR-EMITTER VOLTAGE

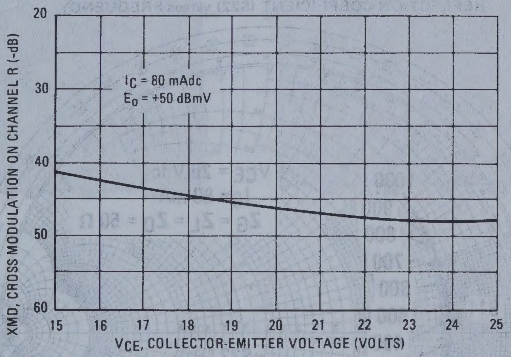


FIGURE 11 – TRIPLE BEAT versus COLLECTOR CURRENT

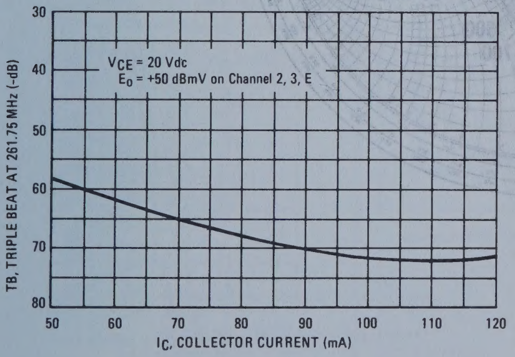


FIGURE 12 – TRIPLE BEAT versus COLLECTOR-EMITTER VOLTAGE

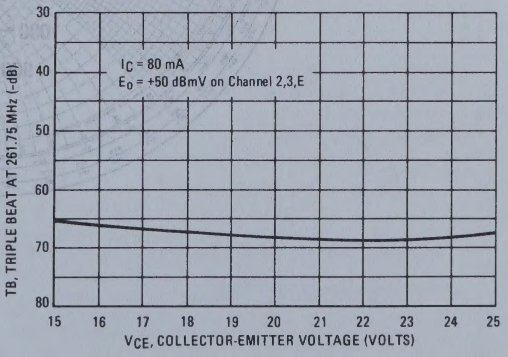


FIGURE 13 – SECOND ORDER IMD versus COLLECTOR CURRENT

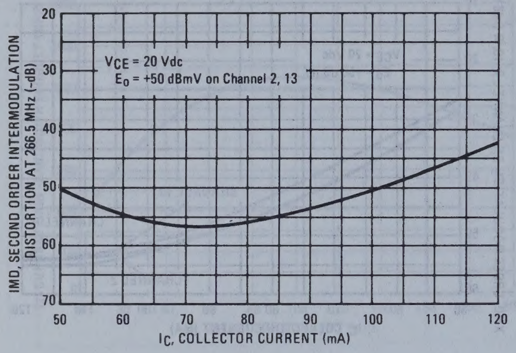


FIGURE 14 – SECOND ORDER IMD versus COLLECTOR-EMITTER VOLTAGE

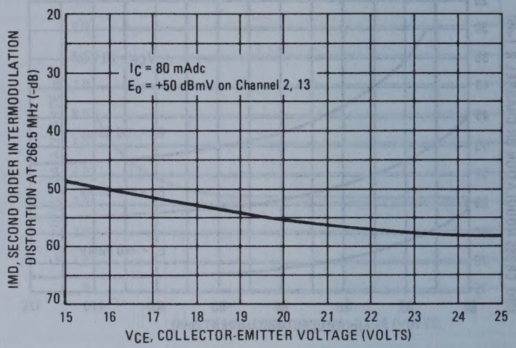


FIGURE 15 – INPUT REFLECTION COEFFICIENT (S11) AND OUTPUT REFLECTION COEFFICIENT (S22) versus FREQUENCY

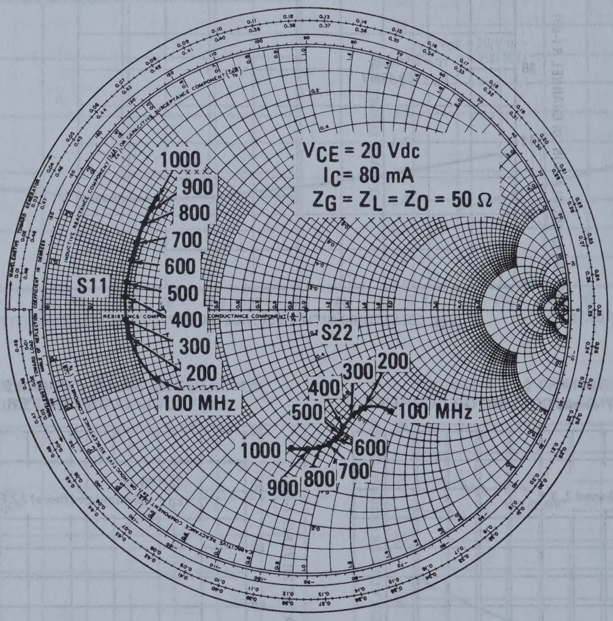


FIGURE 16 – FORWARD TRANSMISSION COEFFICIENT (S12) versus FREQUENCY

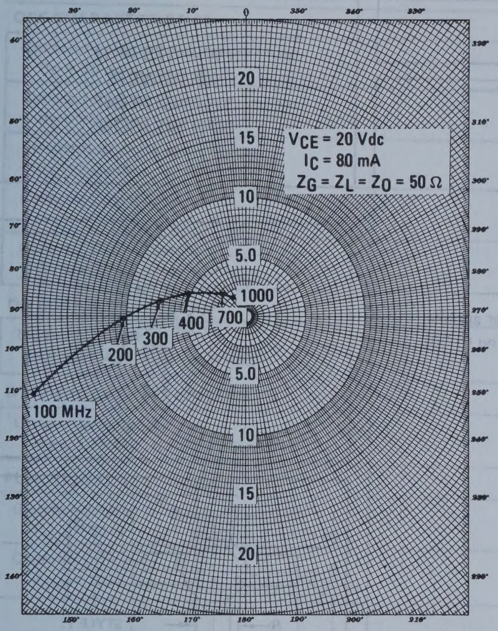
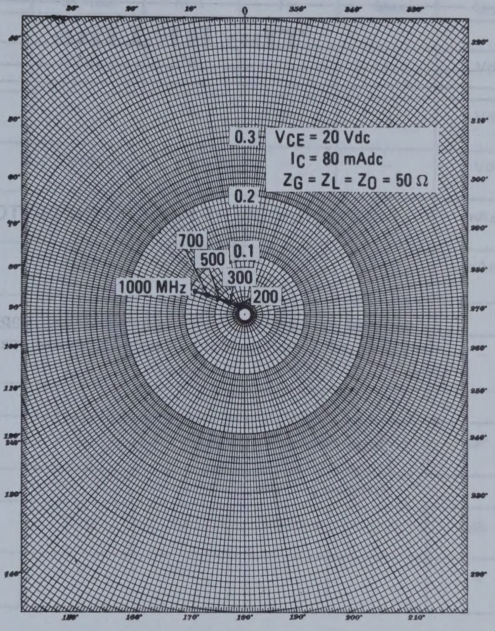


FIGURE 17 – REVERSE TRANSMISSION COEFFICIENT (S21) versus FREQUENCY



MRF603 (SILICON)

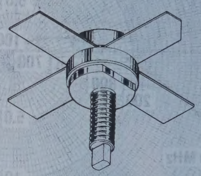
The RF Line

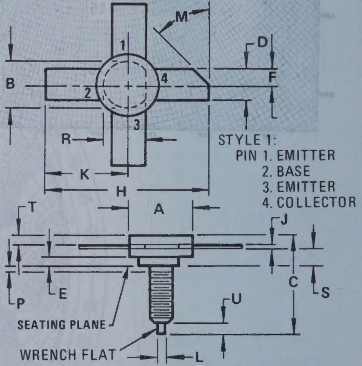
10 W – 175 MHz
RF POWER
TRANSISTOR
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt VHF large-signal power amplifier applications required in military and industrial equipment operating to 300 MHz.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 10 Watts
  Minimum Gain = 10 dB
  Efficiency = 50%





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.78	0.370	0.385
B	8.13	8.38	0.320	0.330
C	18.03	19.05	0.710	0.750
D	5.59	5.84	0.220	0.230
E	1.78	2.03	0.070	0.080
F	2.79	2.92	0.110	0.115
H	26.42	28.70	1.040	1.130
J	0.10	0.15	0.004	0.006
K	13.21	14.35	0.520	0.565
L	1.40	1.65	0.055	0.065
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	7.59	7.80	0.299	0.307
S	4.01	4.52	0.158	0.178
T	2.16	2.41	0.085	0.095
U	2.54	3.30	0.100	0.130

NOTE:
CASE 145A-01 USE 8-32NC2A STUD

CASE 145A-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	30 171	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque (2)	–	6.5	in. lb.

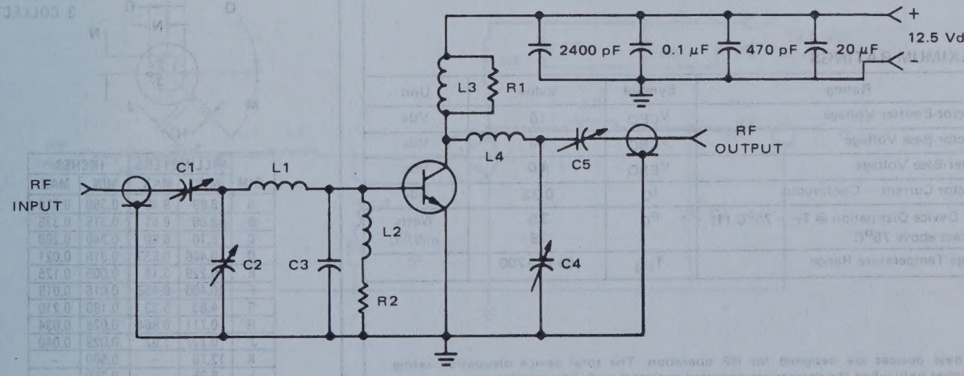
(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

(2) For repeated assembly use 5 in.lb.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	8.0	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	70	85	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 10 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency (P_{out} = 10 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	–	–	%

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1, C5	5.0-80 pF, ARCO 462 or equivalent
C2	9.0-180 pF, ARCO 463 or equivalent
C3	120 pF
C4	25-280 pF, ARCO 464 or equivalent
L1	Copper Strap, 1-1/4" L, 1/4" W, 0.03" Thick
L2	Ferrite Choke VK-200-20/4B FERROXCUBE (Ferrite Bead near Base)
L3	6 Turns # 16 AWG, Wrapped on R1
L4	30 nH, 1 Turn #16 AWG, 1-1/4" Length, 1/4" I.D.
R1	100 Ohms, 2 W
R2	1.5 Ohms, 1/4 W

MRF607 (SILICON)

The RF Line

1.75 W – 175 MHz

RF POWER
TRANSISTOR
NPN SILICON

NPN SILICON RF POWER TRANSISTOR

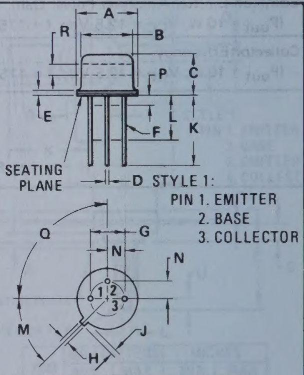
. . . designed for amplifier, frequency multiplier, or oscillator applications in military, mobile, marine and citizens band equipment. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

- Specified 12.5 Volt, 175 MHz Characteristics –
  Output Power = 1.75 Watts
  Minimum Gain = 12.5 dB
  Efficiency = 50%
- Characterized through 225 MHz

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	0.33	Adc
Total Device Dissipation @ $T_C = 75^oC$ (1) Derate above 75°C	P_D	3.5 28	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

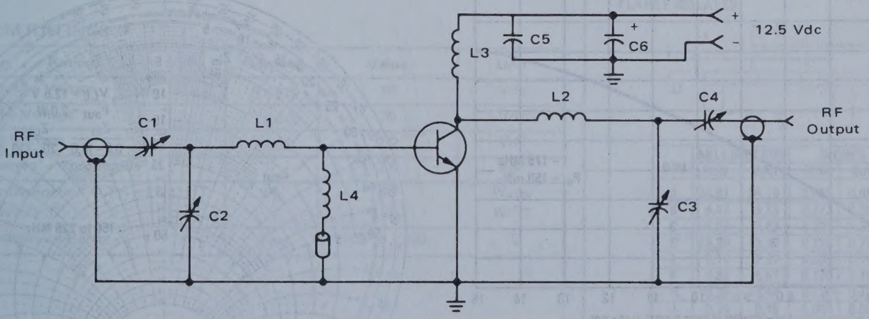
All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, I_B = 0)	BV_{CEO}	16	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.5 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	I_{CEO}	–	0.3	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	20	150	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	15	pF
FUNCTIONAL TEST (Figure 1)				
Common-Emitter Amplifier Power Gain (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	G_{PE}	12.5	–	dB
Collector Efficiency (P_{out} = 1.75 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	50	–	%

FIGURE 1 – 175 MHz TEST CIRCUIT SCHEMATIC



C1	2.7-15 pF, ARCO 461
C2	9.0-180 pF, ARCO 463
C3,C4	5.0-80 pF, ARCO 462
C5	1000 pF UNELCO
C6	5 μF, 25 Vdc, TANTALUM

L1	1 Turn #20 AWG, 3/8″ ID
L2	3 Turns #20 AWG, 3/8″ ID
L3	0.22 μH Molded Choke
L4	0.15 μH Molded Choke with FERROXCUBE 56-590-65-3B Bead on ground lead

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

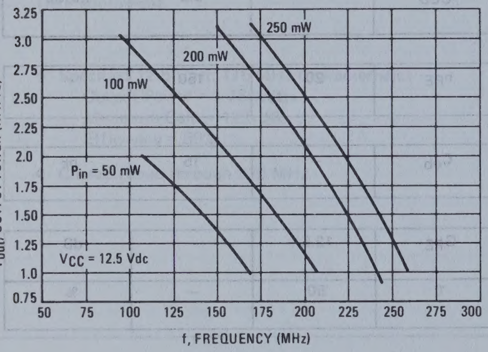


FIGURE 3 – OUTPUT POWER versus INPUT POWER

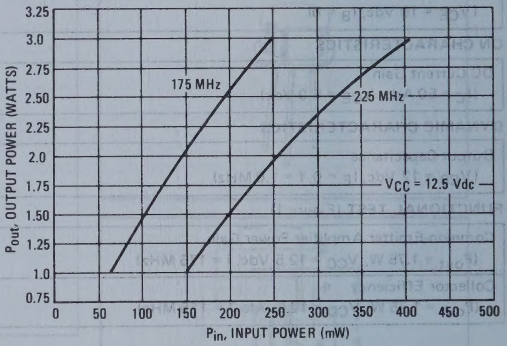


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

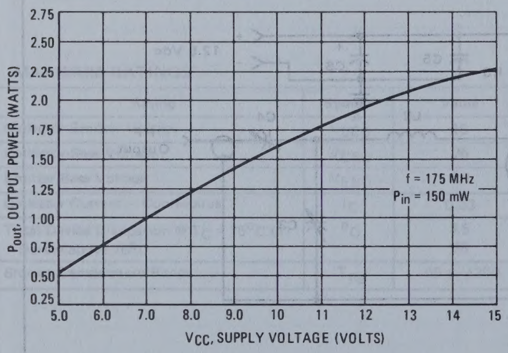
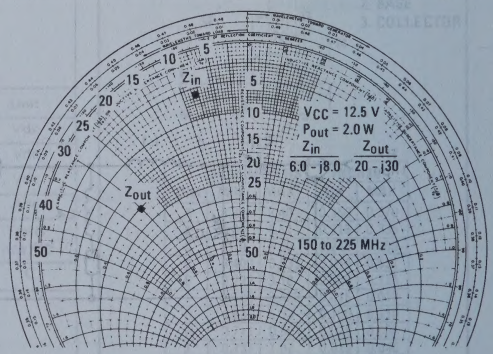


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



MRF618 (SILICON)

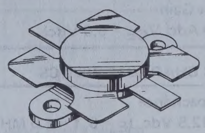
The RF Line

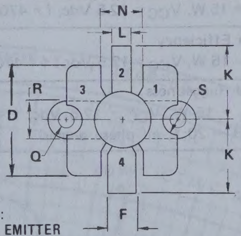
NPN SILICON RF POWER TRANSISTOR

. . .designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 520 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 15 Watts
  Minimum Gain = 6.0 dB
  Efficiency = 60%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized With Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broad Band Operation

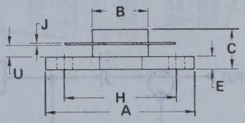
15 W – 470 MHz
CONTROLLED Q
RF POWER
TRANSISTOR
NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

NOTE:
1. DIM "Q" IS DIA
DIM "S" IS RAD



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.51	25.15	0.965	0.990
B	9.47	9.73	0.373	0.383
C	5.97	7.62	0.235	0.300
D	18.29	19.30	0.720	0.760
E	2.16	2.67	0.085	0.105
F	4.32	4.57	0.170	0.180
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	12.19	12.70	0.480	0.500
L	3.05	3.30	0.120	0.130
N	6.86	7.11	0.270	0.280
Q	2.79	3.18	0.110	0.125
R	6.10	6.60	0.240	0.260
S	2.67	3.05	0.105	0.120
U	1.65	1.91	0.065	0.075

CASE 278-02

MAXIMUM RATINGS

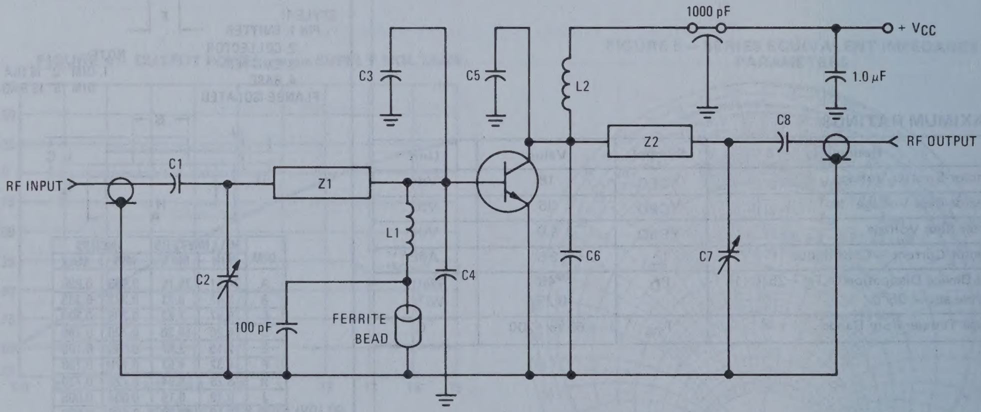
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.5	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	45 0.257	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class B or C RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 55°C)	I_{CES}	–	–	10	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	60	200	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	65	80	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	G_{PE}	6.0	7.0	–	dB
Collector Efficiency (P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 470 MHz)	η	60	–	–	%
Electrical Ruggedness (P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 470 MHz, VSWR = 20:1, all phase angles)	–	No Degradation in Output Power			

FIGURE 1 — 470 MHz TEST CIRCUIT SCHEMATIC



C1, C8 — 100 pF, UNELCO OR EQUIVALENT
C2 — 1.0-10 pF, JOHANSON 2951
C3, C4, C5, C6 — 15 pF, UNELCO OR EQUIVALENT
C7 — 1.0-20 pF, JOHANSON 3906

L1, L2 — 3 TURNS #20 AWG, 1/8″ I.D.
FERRITE BEAD FERROXCUBE 56-590-65-3B

Z1 — 0.2″ WIDTH x 1.0″ LENGTH
Z2 — 0.28″ WIDTH x 1.0″ LENGTH

BOARD IS GLASS TEFLON
3x5 x 0.062 INCH 1 oz COPPER
BOTH SIDES

TYPICAL PERFORMANCE DATA

FIGURE 2 – OUTPUT POWER versus FREQUENCY

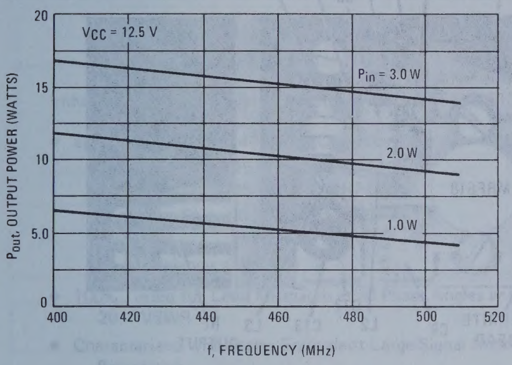


FIGURE 3 – OUTPUT POWER versus INPUT POWER

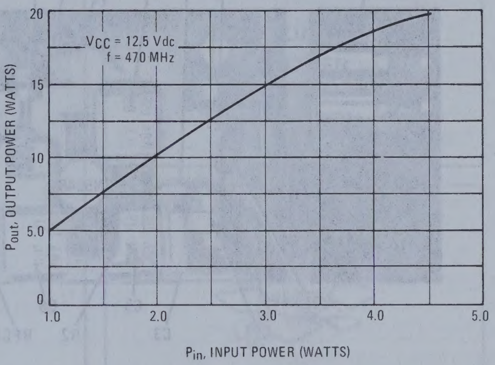


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

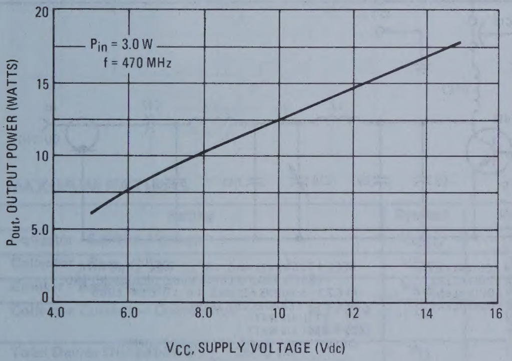


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE PARAMETERS

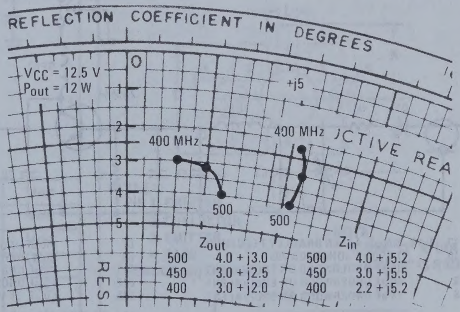
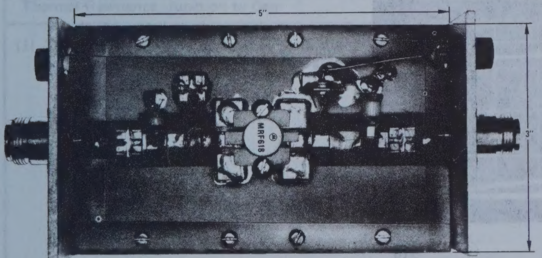


FIGURE 6 – 470 MHz TEST CIRCUIT LAYOUT



The series equivalent impedance values shown in Figure 5 are an average of a large sample of devices. These impedances are highly dependent on the following conditions: input power, output power, supply voltage, harmonic termination and base bias (if any). These variables can cause changes to ±30% from the typical values shown.

Application Note AN-548, "Microstrip Design Techniques for UHF Amplifiers", should be referenced for UHF power amplifier designs.

WIDEBAND UHF AMPLIFIER

460 MHz Typical Performance
P_{in} = 120 mW
P_{out} = 11 W
I_C = 1.8 A

FIGURE 7 –

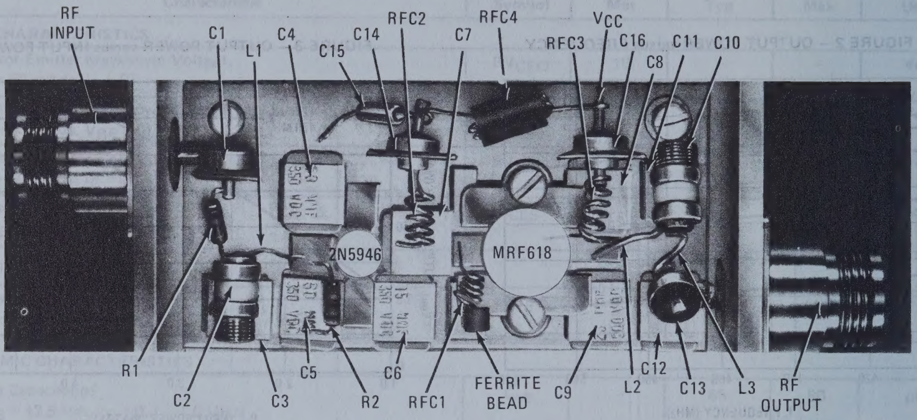
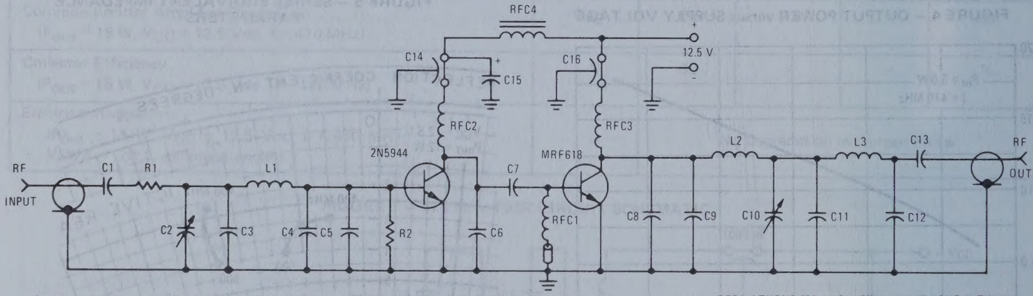

RF INPUT
C1
L1
C4
C15
C14
RFC2
C7
RFC4
V_{CC}
RFC3
C16
C8
C11
C10
2N5946
MRF618
R1
C2
C3
C5
R2
C6
RFC1
FERRITE BEAD
C9
L2
C12
C13
L3
RF OUTPUT

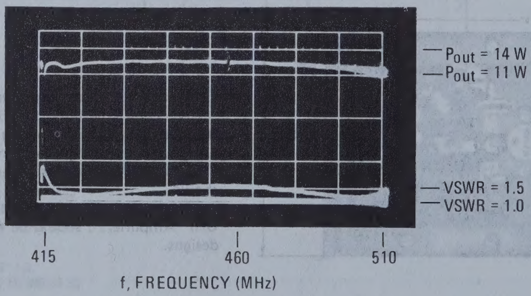
FIGURE 8 –


RFC4
C14
C15
C16
12.5 V
RFC2
RFC3
2N5944
MRF618
RF INPUT
C1
R1
L1
C7
L2
L3
C13
RF OUTPUT
C2
C3
C4
C5
R2
C6
RFC1
C8
C9
C10
C11
C12

C1, 13, 14, 16	680 pF, ALLEN-BRADLEY FEEDTHRU
C2, 10	1.0-10 pF, JOHANSON 2951
C3	10 pF UNDERWOOD OR EQUIVALENT
C4, 5	60 pF UNDERWOOD OR EQUIVALENT
C6, 8	15 pF UNDERWOOD OR EQUIVALENT
C7	100 pF UNDERWOOD OR EQUIVALENT
C9	25 pF UNDERWOOD OR EQUIVALENT
C11	7.0 pF UNDERWOOD OR EQUIVALENT
C12	5.0 pF UNDERWOOD OR EQUIVALENT
C15	1.0 μF 35 V TANTALUM
L1	0.5 INCH, #24 AWG
L2	0.5 INCH, #18 AWG
L3	0.375 INCH, #18 AWG
RFC1	4 TURNS #26 AWG, 1/8" I.D. x 1/4" LONG WITH FERRITE BEAD (FERROXCUBE) ON GROUND END
RFC 2,3	5 TURNS #22 AWG, 1/8" I.D. x 1/4" LONG
RFC 4	FERROXCUBE VK200
R1	2.7 Ω 1/4 WATT
R2	3.9 Ω 1/4 WATT

CIRCUIT BUILT ON P.C. BOARD 2 OZ COPPER

FIGURE 9 – WIDEBAND SWEPT RESPONSE



SWEPT POWER OUTPUT AND INPUT VSWR V_{CC} = 12.5 V P_{in} 150 mW

MRF619 (SILICON)
MRF620

The RF Line

NPN SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 510 MHz.

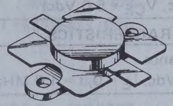
- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 25 Watts – MRF619
  35 Watts – MRF620
  Minimum Gain = 5.22 dB – MRF619
  4.3 dB – MRF620
  Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Built-In Matching Network for Broadband Operation

25 W – 470 MHz – MRF619
35 W – 470 MHz – MRF620

"CONTROLLED Q"

RF POWER TRANSISTORS

NPN SILICON



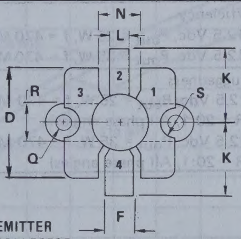
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector - Emitter Voltage		V_{CEO}	16	Vdc
Collector - Base Voltage		V_{CBO}	36	Vdc
Emitter - Base Voltage		V_{EBO}	4.0	Vdc
Collector Current — Continuous	MRF619 MRF620	I_C	6.0 8.0	Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ (1) Derate above $25^{\circ}C$		P_D	115 0.667	Watts W/°C
Storage Temperature Range		T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

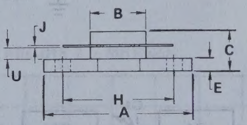
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	°C/W

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as class C RF amplifiers.



STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

NOTE:
1. DIM "Q" IS DIA
DIM "S" IS RAD



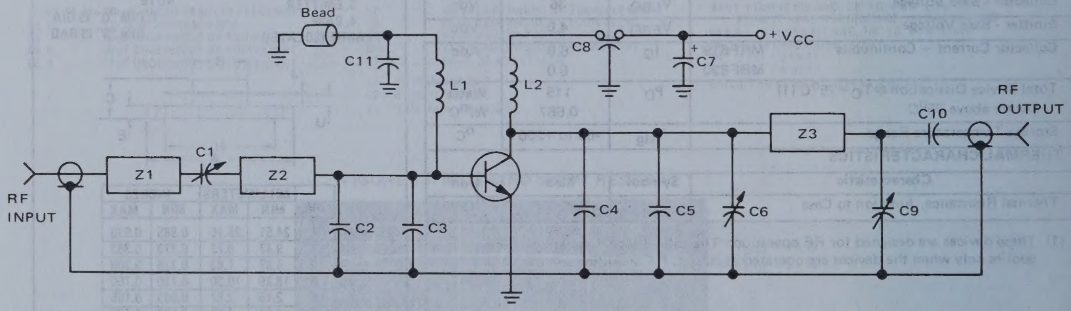
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.51	25.15	0.965	0.990
B	9.47	9.73	0.373	0.383
C	5.97	7.62	0.235	0.300
D	18.29	19.30	0.720	0.760
E	2.16	2.67	0.085	0.105
F	4.32	4.57	0.170	0.180
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	12.19	12.70	0.480	0.500
L	3.05	3.30	0.120	0.130
N	6.86	7.11	0.270	0.280
Q	2.79	3.18	0.110	0.125
R	6.10	6.60	0.240	0.260
S	2.67	3.05	0.105	0.120
U	1.65	1.91	0.065	0.075

CASE 278-02

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 15 mAdc, I_B = 0)	BV_{CEO}	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	–	20	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	20	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	30	60	150	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	85	95	pF
FUNCTIONAL TEST (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz) MRF619 (V_{CC} = 12.5 Vdc, P_{out} = 35 W, f = 470 MHz) MRF620	G_{PE}	 5.22 4.3	 – –	 – –	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz) MRF619 (V_{CC} = 12.5 Vdc, P_{out} = 35 W, f = 470 MHz) MRF620	η	 55 55	 – –	 – –	%
Electrical Ruggedness (V_{CC} = 12.5 Vdc, P_{out} = 25 W, f = 470 MHz, VSWR = 20:1, All phase angles) MRF619 (V_{CC} = 12.5 Vdc, P_{out} = 35 W, f = 470 MHz, VSWR = 20:1, All phase angles) MRF620	–	No Degradation in output power			

FIGURE 1 – 470 MHz TEST CIRCUIT



C1, C9	1.0–20 pF JOHANSON 3906 or equivalent
C2, C4	25 pF UNELCO or equivalent
C3, C5	15 pF UNELCO or equivalent
C6	1.0–10 pF JOHANSON 2951 or equivalent
C7	1.0 μF, 35 V TANTALUM
C8	680 pF Feedthru
C10, C11	100 pF UNELCO or equivalent

L1	4 Turns #22 AWG, 0.125 I.D.
L2	3 Turns #20 AWG, 0.250 I.D.
Z1	0.160″ W X 1.7″ L
Z2	0.230″ W X 0.9″ L
Z3	0.340″ W X 0.9″ L

FERROXCUBE Bead 56-590-65-3B
Board is glass teflon, ϵ_R = 2.56
3″ x 5″ x 0.062″, 1 oz.
COPPER DOUBLE CLAD

OUTPUT POWER versus FREQUENCY

(V_{CC} = 12.5 Vdc)

FIGURE 2 – MRF619

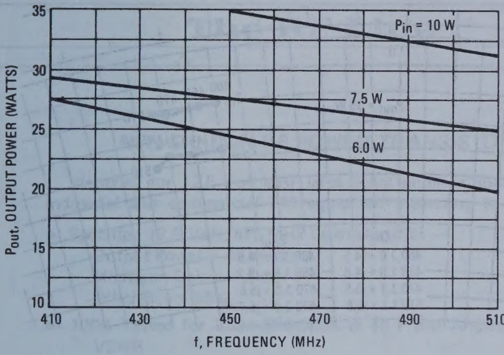
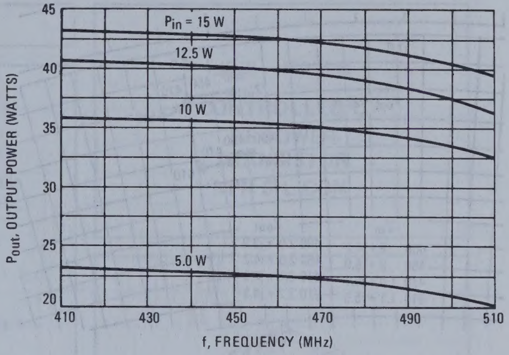


FIGURE 3 – MRF620



OUTPUT POWER versus INPUT POWER

(V_{CC} = 12.5 Vdc)

FIGURE 4 – MRF619

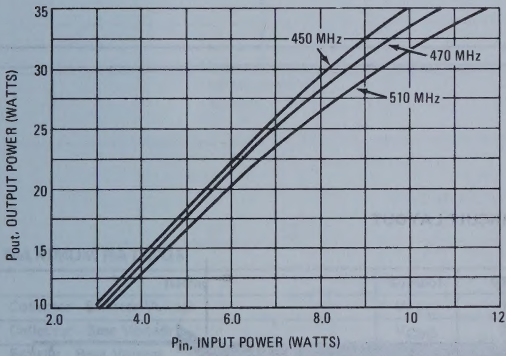
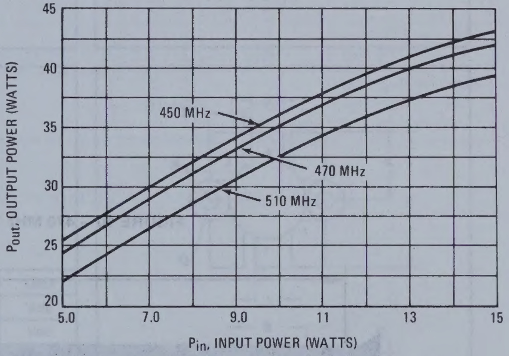


FIGURE 5 – MRF620



OUTPUT POWER versus SUPPLY VOLTAGE

(f = 470 MHz)

FIGURE 6 – MRF619

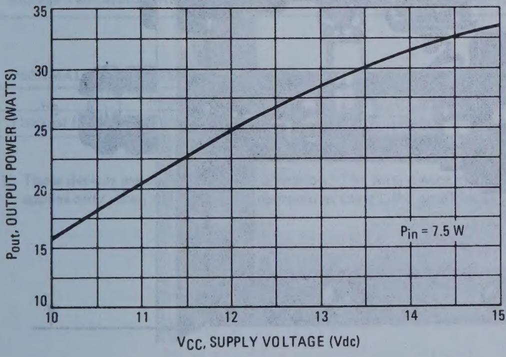
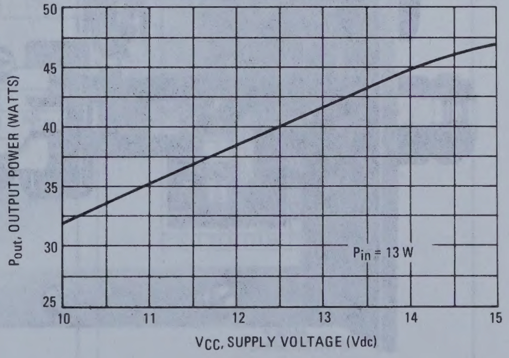


FIGURE 7 – MRF620



SERIES EQUIVALENT IMPEDANCE

(V_{CC} = 12.5 Vdc)

FIGURE 8 — MRF619

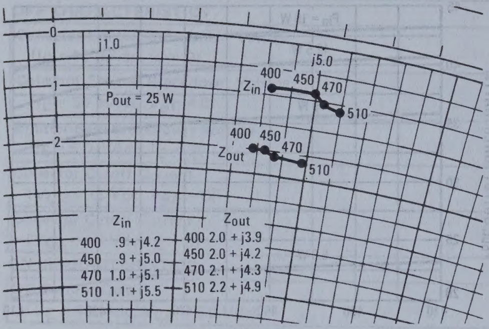


FIGURE 9 — MRF620

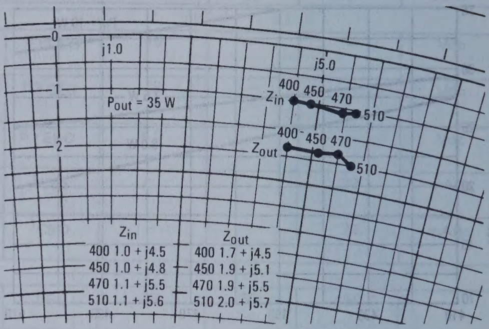
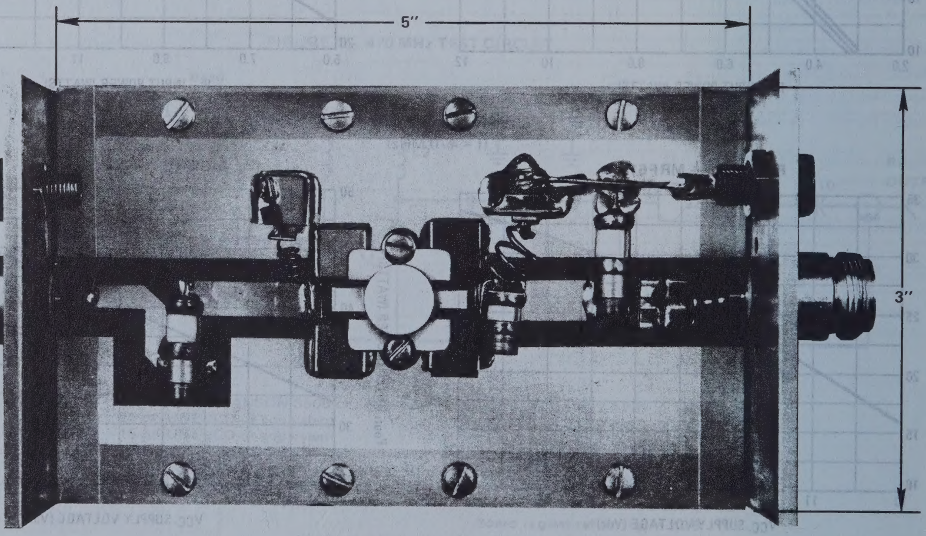


FIGURE 10 — 470 MHz TEST CIRCUIT LAYOUT



MRF621 (SILICON)

The RF Line

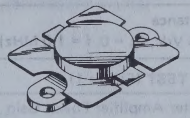
NPN SILICON RF POWER TRANSISTOR

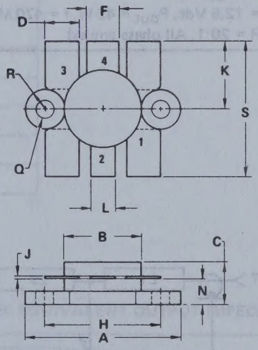
. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 512 MHz.

- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 45 Watts
  Minimum Gain = 4.8 dB
  Efficiency = 55%
- 100% Tested for Load Mismatch at all Phase Angles with 20:1 VSWR
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Built-in Matching Network for Broadband Operation.

45 W – 470 MHz

"CONTROLLED Q"
RF POWER
TRANSISTOR
NPN SILICON





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	24.38	25.15	0.960	0.990
B	12.45	12.95	0.490	0.510
C	5.97	7.62	0.235	0.300
D	5.46 TYP		0.215 TYP	
F	5.08	5.33	0.200	0.210
H	18.29	18.54	0.720	0.730
J	0.10	0.15	0.004	0.006
K	10.67	10.92	0.420	0.430
L	3.81	4.06	0.150	0.160
N	3.81	4.32	0.150	0.170
Q	2.92	3.18	0.115	0.125
R	3.05	3.30	0.120	0.130
S	21.34	21.84	0.840	0.860

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. EMITTER
4. BASE
FLANGE-ISOLATED

CASE 278-03

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector - Emitter Voltage	V_{CEO}	16	Vdc
Collector - Base Voltage	V_{CBO}	36	Vdc
Emitter - Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	11	Adc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	146 0.834	Watts $W/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

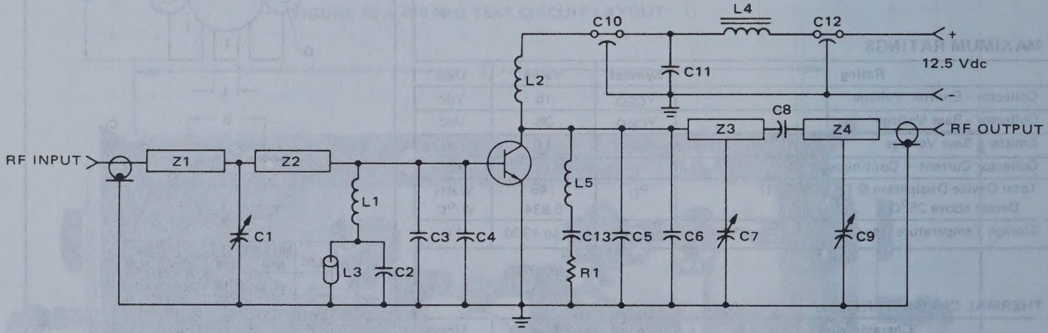
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.2	$^oC/W$

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	16	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 15 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	20	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	130	pF
FUNCTIONAL TEST (Figure 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 45 W, $I_{C(max)}$ = 6.5 Adc, f = 470 MHz)	G_{PE}	4.8	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 45 W, $I_{C(max)}$ = 6.5 Adc, f = 470 MHz)	η	55	–	%
Electrical Ruggedness (V_{CC} = 12.5 Vdc, P_{out} = 45 W, f = 470 MHz, VSWR = 20:1, All phase angles)	–	No Degradation in output power		–

FIGURE 1 – 470 MHz TEST CIRCUIT



C1, C9	1.0-20 pF JOHANSON Type 3906
C2,C8	100 pF UNELCO
C3,C4,C5	25 pF UNELCO
C6	40 pF UNELCO
C7	5.0 pF UNELCO
C10,C12	680 pF ALLEN BRADLEY Feedthru
C11	1.0 µF, 35 V TANTALUM
C13	0.1 µF, 100 V ERIE Red Cap
L1	3.9 µH DELEVAN Molded Choke
L2	7 Turns, #18 AWG, 0.2″ ID x 0.5″ L (0.5 cm ID x 1.3 cm L)
L3	FERRITE Bead on Lead of L1 FERROXCUBE 56-590-65-3B
L4	FERRITE Choke, FERROXCUBE VK200-20-4B
L5	2 Turns, Lead of C13, 0.1″ ID (0.25 cm)
R1	4.3 Ohm, 1/4 Watt, 10%
Z1,Z4	Microstrip Line (50 Ω), 0.180″ W (0.07 cm)
Z2	Microstrip Line, 0.25″ W x 1.0″ L (0.7 cm W x 2.5 cm L)
Z3	Microstrip Line, 0.25″ W x 1.5″ L (0.7 cm W x 3.8 cm L)

C7 Mounted 1.0″ (2.5 cm) from C5, C6

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062″

Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

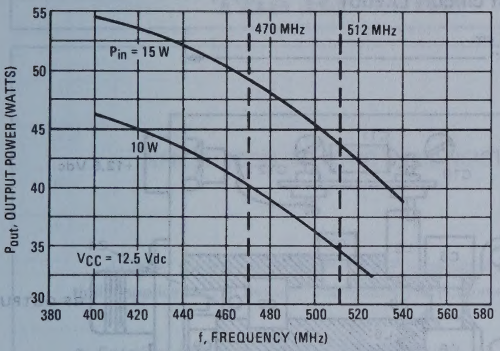


FIGURE 3 – OUTPUT POWER versus INPUT POWER

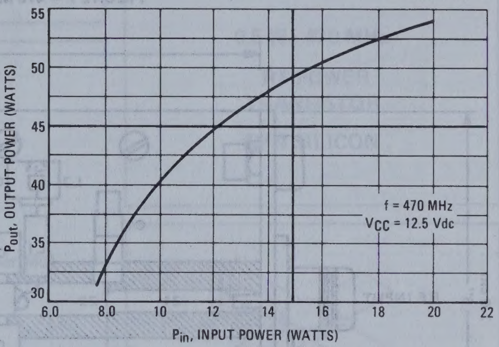


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

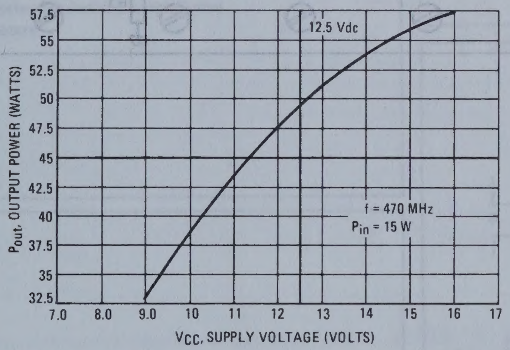


FIGURE 5 – SERIES EQUIVALENT INPUT IMPEDANCE

P_{out} = 45 W
V_{CC} = 12.5 Vdc

Frequency MHz	Z_{IN} Ohms
400	1.3 + j3.9
450	1.4 + j4.1
500	1.9 + j5.7
550	3.7 + j4.5

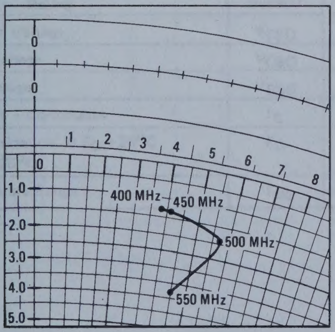


FIGURE 6 – SERIES EQUIVALENT OUTPUT IMPEDANCE

P_{out} = 45 W
V_{CC} = 12.5 Vdc

Frequency MHz	Z_{OL} Ohms
400	1.9 + j2.3
450	1.7 + j2.4
500	1.6 + j2.4
550	1.2 + j3.4

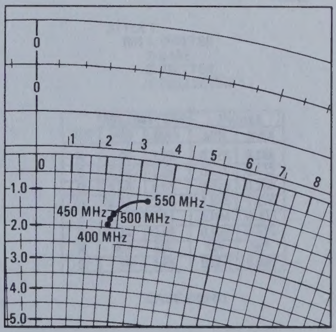
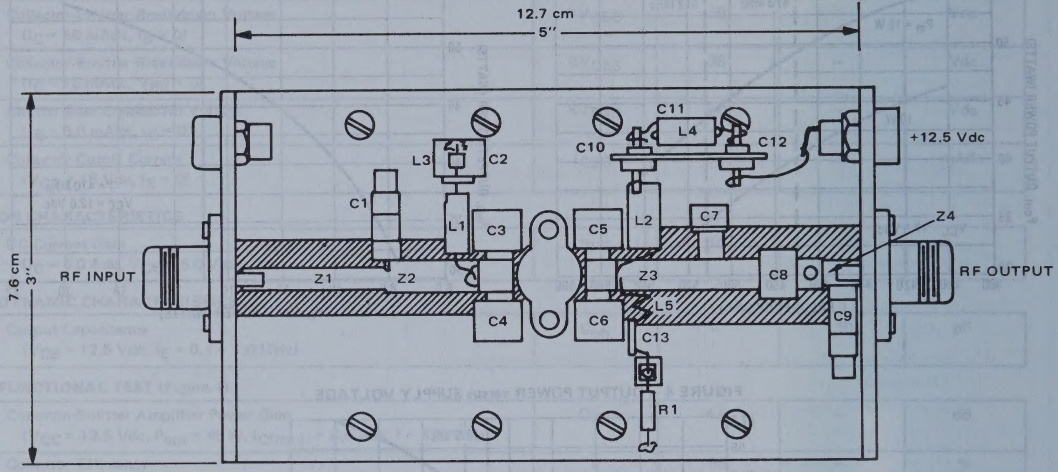


FIGURE 7 — 470 MHz TEST CIRCUIT LAYOUT


12.7 cm
5″
7.6 cm
3″
RF INPUT
RF OUTPUT
+12.5 Vdc
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
L1
L2
L3
L4
L5
Z1
Z2
Z3
Z4
R1

MRF628 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

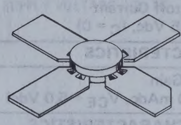
. . . designed for 5.0 - 15 Volt, VHF/UHF large-signal Amplifier/Multiplier applications in military and mobile FM equipment.

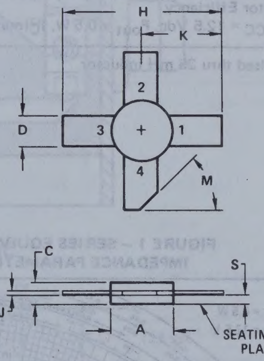
- Specified 12.5 Volt, 470 MHz Characteristics
  Power Output = 0.5 Watts
  Minimum Gain = 10 dB
  Efficiency = 50%
- Characterized with Series Equivalent Large-Signal Impedance Parameters

0.5 W - 470 MHz

RF POWER TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
C	2.92	3.35	0.115	0.132
D	5.59	5.84	0.220	0.230
H	26.67	27.18	1.050	1.070
J	0.10	0.15	0.004	0.006
K	13.34	13.59	0.525	0.535
M	40°	50°	40°	50°
S	1.40	1.65	0.055	0.065

CASE 249-01

MAXIMUM RATINGS

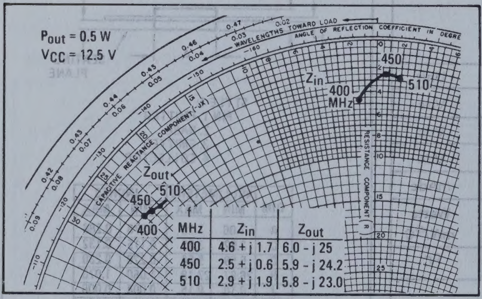
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate Above 25^oC	P_D	3.0 17.2	Watts mW/^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

ELECTRICAL CHARACTERISTICS ($T_C = 25^{o}C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 20 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 20 mAdc, I_E = 0)	BV_{CBO}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 25°C)	I_{CES}	–	–	2.0	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_C = 0)	I_{CBO}	–	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	6.0	10	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, I_C(max) = 80 mAdc, f = 470 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.5 W, I_C(max) = 80 mAdc, f = 470 MHz)	η	50	–	–	%

(1) Pulsed thru 25 mH inductor.

FIGURE 1 – SERIES EQUIVALENT IMPEDANCE PARAMETERS



f MHz	Z_{in}	Z_{out}
400	4.6 + j 1.7	6.0 - j 25
450	2.5 + j 0.6	5.9 - j 24.2
510	2.9 + j 1.9	5.8 - j 23.0

FIGURE 2 – OUTPUT POWER versus INPUT POWER

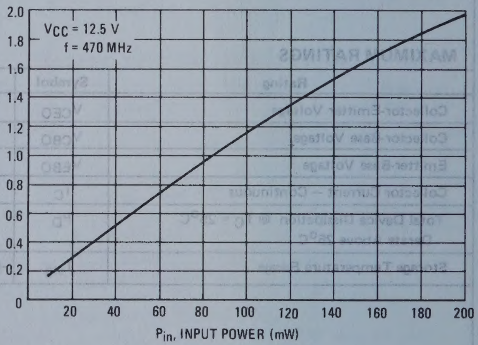


FIGURE 3 – OUTPUT POWER versus FREQUENCY

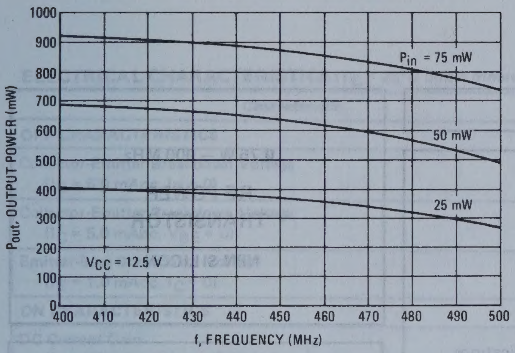


FIGURE 4 – OUTPUT POWER versus VOLTAGE

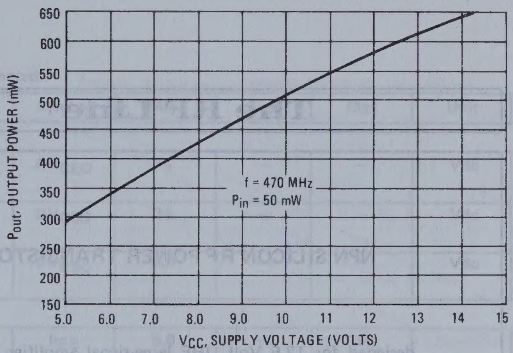


FIGURE 5 – 470 MHz TEST CIRCUIT

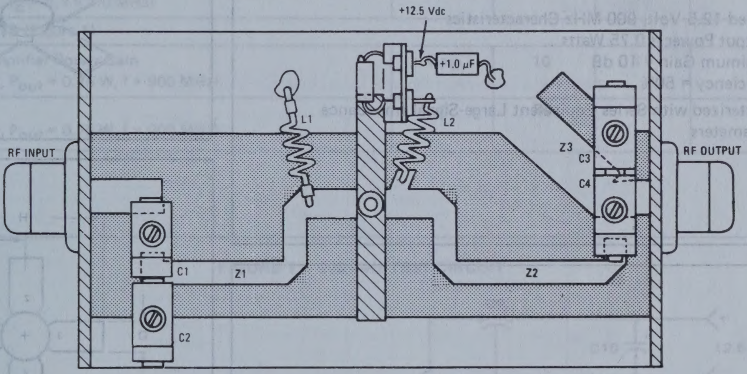
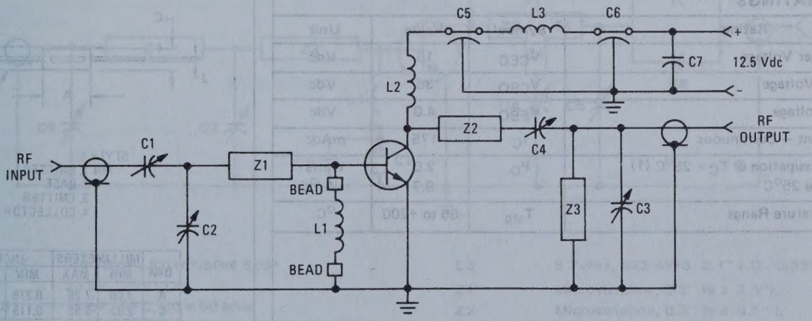

+12.5 Vdc
+1.0 μF
L1
L2
RF INPUT
RF OUTPUT
Z3
C3
C4
C1
Z1
Z2
C2

FIGURE 6 – 470 MHz TEST CIRCUIT SCHEMATIC


C5
L3
C6
+
C7
12.5 Vdc
–
L2
Z2
C4
RF OUTPUT
C1
RF INPUT
Z1
BEAD
L1
BEAD
C2
Z3
C3

C1,2,3,4	1.0-25 pF ARCO 421 OR EQUIVALENT
C5,6	1000 pF FEEDTHRU CAPACITOR
C7	1.0 μF, 35 V CAPACITOR
L1,2	7 TURNS #22 AWG, 0.2" I.D. FERRITE BEADS FERROXCUBE 56-590-65-3B AS SHOWN ON L1
L3	1-CHOKE FERROXCUBE VK-200-20-4B

BOARD-GLASS TEFLON, $\epsilon_R = 2.56$, t = 0.062
MOUNTING PLATE – 3" x 5" x 0.060"
INPUT/OUTPUT CONNECTORS – TYPE N

MRF816 (SILICON)

The RF Line

0.75 W – 900 MHz

RF POWER TRANSISTOR

NPN SILICON

NPN SILICON RF POWER TRANSISTOR

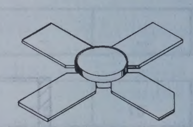
. . . designed for 12.5 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 960 MHz.

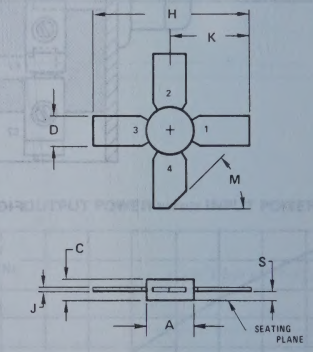
- Specified 12.5 Volt, 900 MHz Characteristics –
  Output Power = 0.75 Watts
  Minimum Gain = 10 dB
  Efficiency = 50%
- Characterized with Series Equivalent Large-Signal Impedance Parameters

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	175	mAdc
Total Device Dissipation @ $T_C = 25^oC$ (1) Derate above 25^oC	P_D	2.0 8.7	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

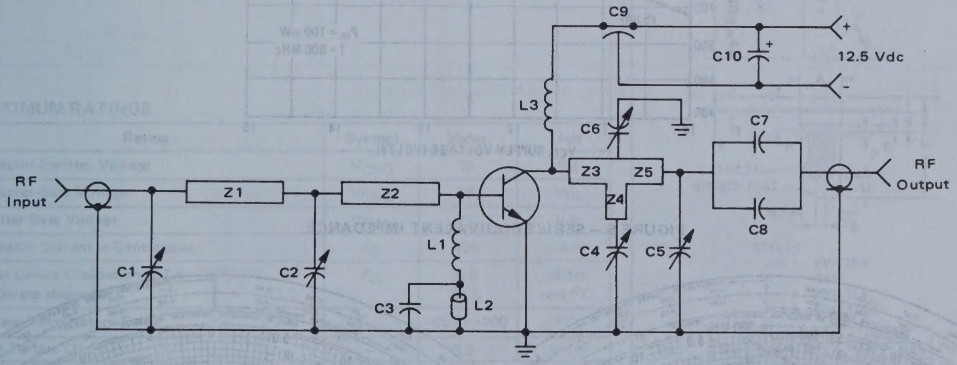
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
C	2.92	3.35	0.115	0.132
D	5.59	5.84	0.220	0.230
H	26.67	27.18	1.050	1.070
J	0.10	0.15	0.004	0.006
K	13.34	13.59	0.525	0.535
M	40°	50°	40°	50°
S	1.40	1.65	0.055	0.065

CASE 249-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	16	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	150	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	3.0	5.0	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 900 MHz)	G_{PE}	10	11	–	dB
Collector Efficiency (V_{CC} = 12.5 Vdc, P_{out} = 0.75 W, f = 900 MHz)	η	50	–	–	%

FIGURE 1 – 900 MHz TEST CIRCUIT



C1,2,4,5,6	1.0-10 pF, JOHANSON 5201
C3	25 pF, UNELCO
C7,C8	15 pF, ATC, 50 x 50 Mils
C9	680 pF, ALLEN BRADLEY Feedthru
C10	1.0 μF, 35 V, TANTALUM
L1	6 Turns, #26 AWG, 0.1" I.D., 0.25" Long, Bead on ground lead
L2	Ferrite Bead, FERROXCUBE, 56-590-65-3B on Lead of L1

L3	5 Turns, #22 AWG, 0.1" I.D., 0.35" Long
Z1	Microstripline, 0.3" W x 2.0" L
Z2	Microstripline, 0.3" W x 0.5" L
Z3,Z4	Microstripline, 0.3" W x 0.6" L
Z5	Microstripline, 0.3" W x 0.4" L

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062"
Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus INPUT POWER

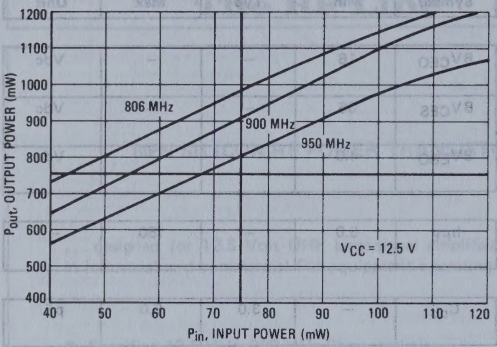


FIGURE 3 – OUTPUT POWER versus FREQUENCY

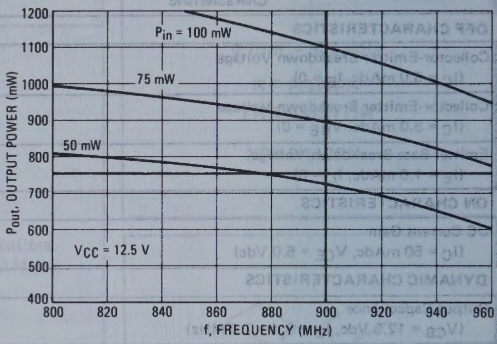


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

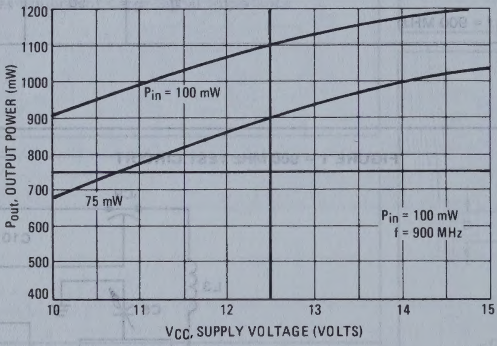
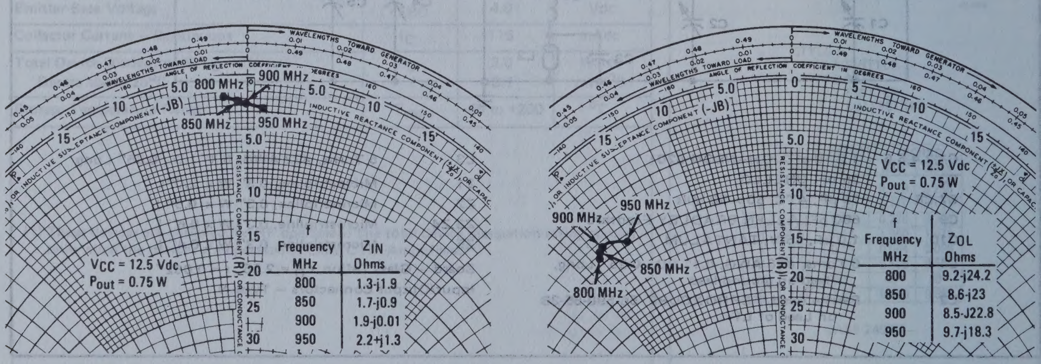


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



f Frequency MHz	Z_{IN} Ohms
800	1.3-j1.9
850	1.7-j0.9
900	1.9-j0.01
950	2.2+j1.3

f Frequency MHz	Z_{OL} Ohms
800	9.2-j24.2
850	8.6-j23
900	8.5-J22.8
950	9.7-j18.3

MRF817 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

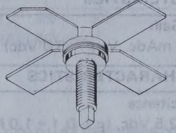
. . . designed for 13.6 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 960 MHz.

- Specified 13.6 Volt, 900 MHz Characteristics –
  Output Power = 2.5 Watts
  Minimum Gain = 6.2 dB
  Efficiency = 50%
- Characterized with Series Equivalent Large-Signal Impedance Parameters

2.5 W – 900 MHz

RF POWER
TRANSISTOR

NPN SILICON

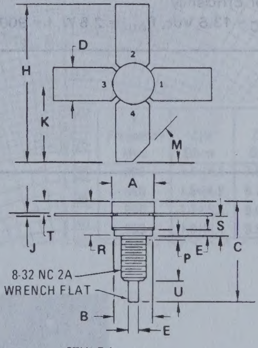


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque (2)	–	6.5	In. Lb.

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF Amplifiers.

(2) For repeated assembly, use 5 In. Lb.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

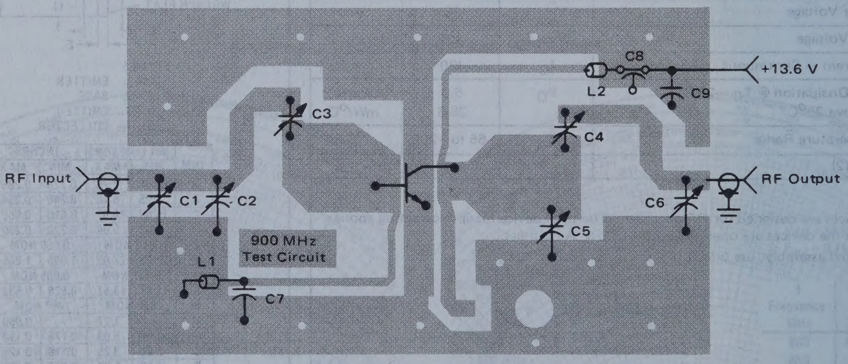
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.25	6.45	0.246	0.254
C	15.49	16.51	0.610	0.650
D	5.59	5.84	0.220	0.230
E	1.52 NOM		0.060 NOM	
H	26.80	27.05	1.055	1.065
J	0.127 NOM		0.005 NOM	
K	13.41	13.51	0.528	0.532
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	4.52	5.03	0.178	0.198
S	3.00	3.25	0.118	0.128
T	1.40	1.65	0.055	0.065
U	2.92	3.68	0.115	0.145

CASE 244

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 50$ mAdc, $I_B = 0$)	BV_{CEO}	16	–	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 50$ mAdc, $V_{BE} = 0$)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0$ mAdc, $I_C = 0$)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)	I_{CBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	40	200	–
DYNAMIC CHARACTERISTICS				
Output Capacitance ($V_{CB} = 12.5$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	–	15	pF
FUNCTIONAL TESTS (Figure 1)				
Common-Emitter Amplifier Power Gain ($V_{CC} = 13.6$ Vdc, $P_{out} = 2.5$ W, f = 900 MHz)	G_{PE}	6.2	–	dB
Collector Efficiency ($V_{CC} = 13.6$ Vdc, $P_{out} = 2.5$ W, f = 900 MHz)	η	50	–	%

FIGURE 1 – 900 MHz TEST CIRCUIT



Microstrip Board

C1,4	1.0-20 pF, JOHANSON S501
C2,3,5,6	1.0-10 pF, JOHANSON S201
C7	100 pF UNELCO
C8	680 pF, ALLEN BRADLEY Feedthru
C9	1.0 µF, 35 V TANTALUM
L1,2	Ferrite Bead FERROXCUBE 56-590-65-4A on 1/2", #22 AWG

Board – Glass Teflon, $\epsilon_R = 2.56$, t = 0.062"
Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus INPUT POWER

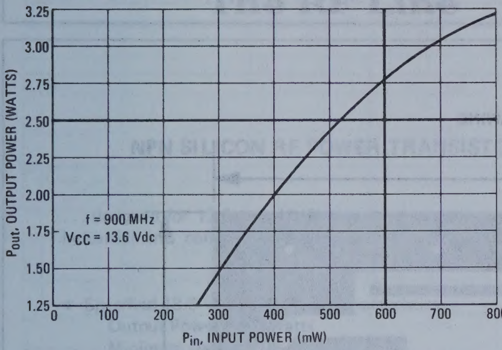


FIGURE 3 – OUTPUT POWER versus FREQUENCY

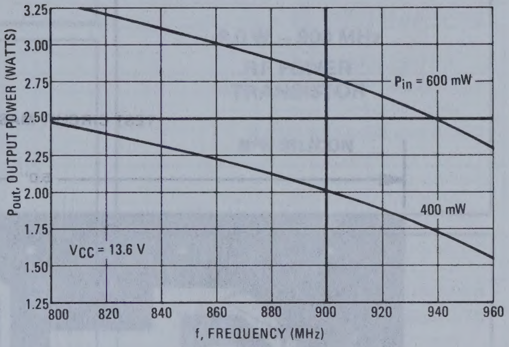


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

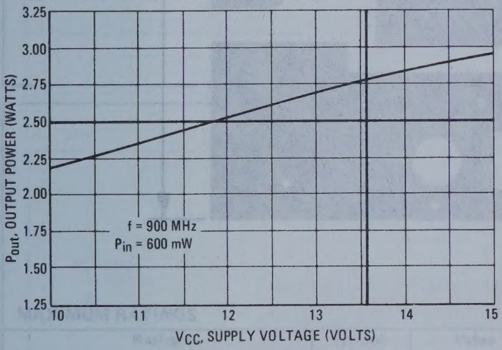
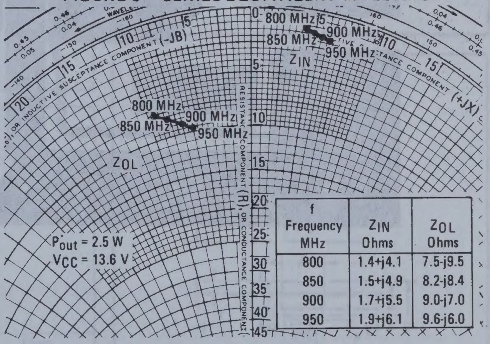
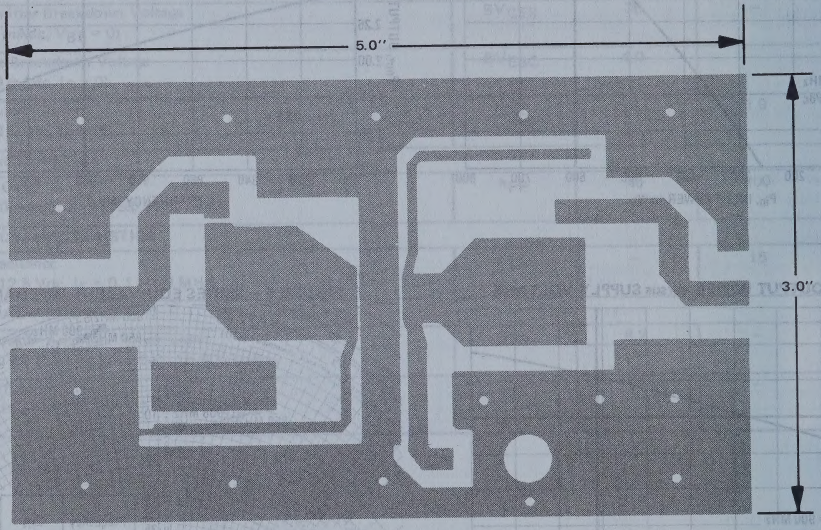


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



f Frequency MHz	Z_{IN} Ohms	Z_{OL} Ohms
800	1.4+j4.1	7.5-j9.5
850	1.5+j4.9	8.2-j8.4
900	1.7+j5.5	9.0-j7.0
950	1.9+j6.1	9.6-j6.0

TEST CIRCUIT MASK DRAWING



MRF818 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

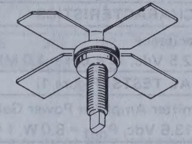
. . . designed for 13.6 Volt UHF large-signal amplifier applications in industrial and commercial FM equipment operating to 960 MHz.

- Specified 13.6 Volt, 900 MHz Characteristics –
  Output Power = 8.0 Watts
  Minimum Gain = 5.05 dB
  Efficiency = 50%
- Characterized with Series Equivalent Large-Signal Impedance Parameters

8.0 W – 900 MHz

RF POWER TRANSISTOR

NPN SILICON

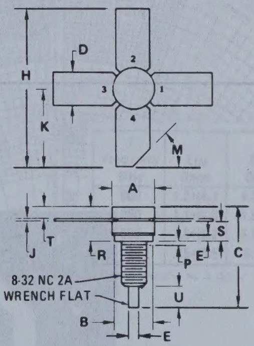


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	16	Vdc
Collector-Base Voltage	V_{CBO}	36	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	1.5	Adc
Total Device Dissipation @ $T_C = 25°C$, (1) Derate Above 25°C	P_D	15 85.7	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque (2)	–	6.5	In-Lb

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as Class C RF amplifiers.

(2) For repeated assembly, use 5 In. Lb.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

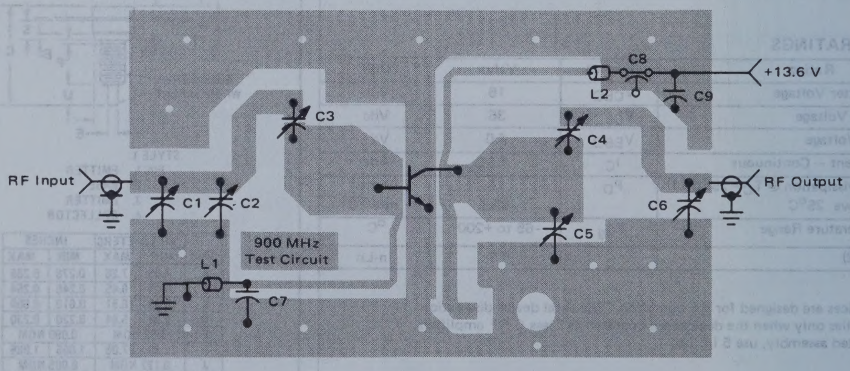
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.25	6.45	0.246	0.254
C	15.49	16.51	0.610	0.650
D	5.59	5.84	0.220	0.230
E	1.52 NOM		0.060 NOM	
H	26.80	27.05	1.055	1.065
J	0.127 NOM		0.005 NOM	
K	13.41	13.51	0.528	0.532
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	4.52	5.03	0.178	0.198
S	3.00	3.25	0.118	0.128
T	1.40	1.65	0.055	0.065
U	2.92	3.68	0.115	0.145

CASE 244

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted).

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	16	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	40	200	–
DYNAMIC CHARACTERISTICS				
Output Capacitance V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz	C_{ob}	–	25	pF
FUNCTIONAL TESTS (Figure 1)				
Common-Emitter Amplifier Power Gain (V_{CC} = 13.6 Vdc, P_{out} = 8.0 W, f = 900 MHz)	G_{PE}	5.05	–	dB
Collector Efficiency (V_{CC} = 13.6 Vdc, P_{out} = 8.0 W, f = 900 MHz)	η	50	–	%

FIGURE 1 – 900 MHz TEST CIRCUIT



Microstrip Board

C1,4	1.0-20 pF, JOHANSON S501
C2,3,5,6	1.0-10 pF, JOHANSON S201
C7	100 pF UNELCO
C8	680 pF, ALLEN BRADLEY Feedthru
C9	1.0 μF, 35 V TANTALUM

L1,2 Ferrite Bead FERROXCUBE 56-590-65-4A on 1/2″, #22 AWG

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062″

Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus INPUT POWER

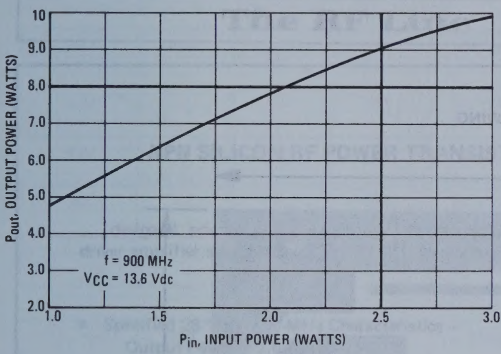


FIGURE 3 – OUTPUT POWER versus FREQUENCY

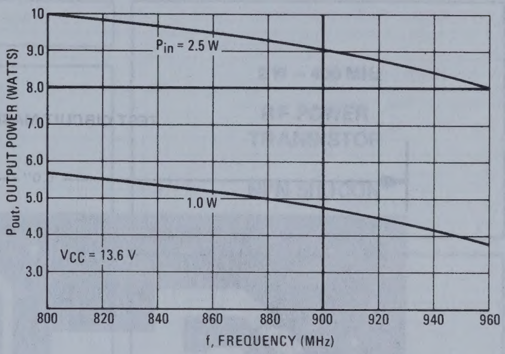


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

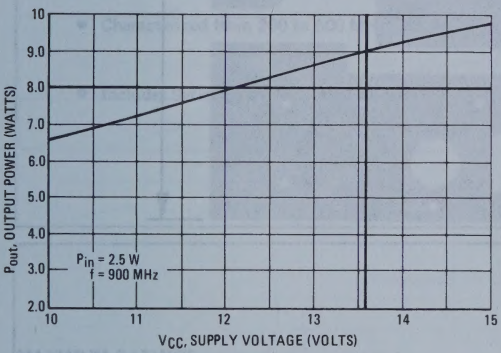
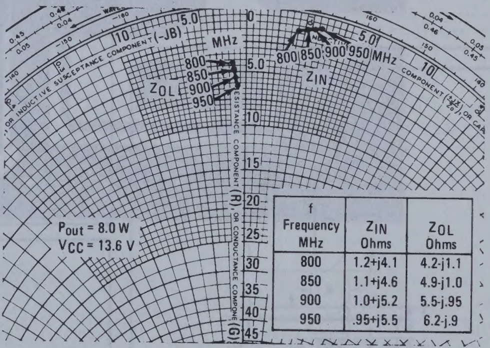
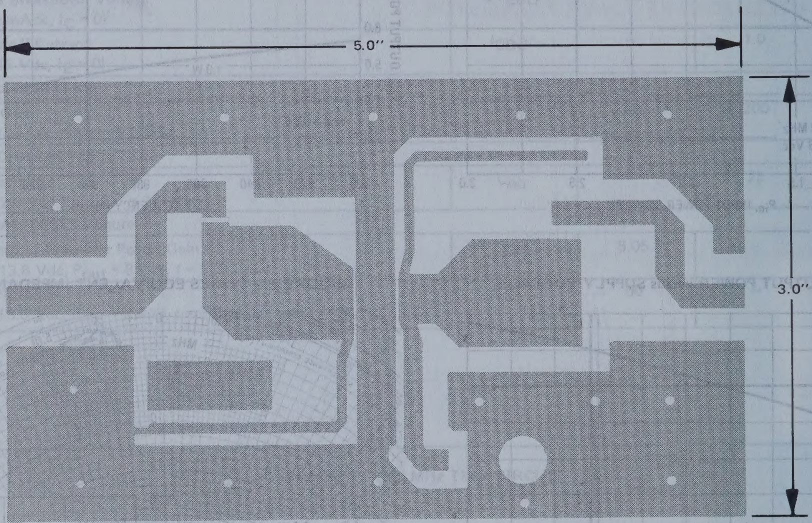


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



f Frequency MHz	Z_{IN} Ohms	Z_{OL} Ohms
800	1.2+j4.1	4.2-j1.1
850	1.1+j4.6	4.9-j1.0
900	1.0+j5.2	5.5-j.95
950	.95+j5.5	6.2-j.9


TEST CIRCUIT MASK DRAWING
5.0″
3.0″

MRF5174 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

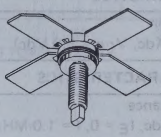
. . . designed primarily for wideband large-signal driver and pre-driver amplifier stages in the 200-600 MHz frequency range.

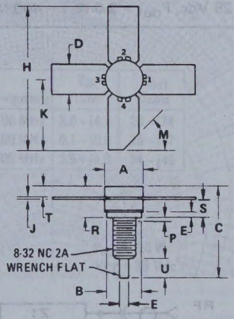
- Specified 28-Volt, 400-MHz Characteristics –
  Output Power = 2.0 Watts
  Minimum Gain = 12 dB
  Efficiency = 50%
- Characterized from 200 to 600 MHz
- Includes Series Equivalent Impedances

2 W – 400 MHz

RF POWER TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.25	6.45	0.246	0.254
C	15.49	16.51	0.610	0.650
D	5.59	5.84	0.220	0.230
E	1.52 NOM		0.060 NOM	
H	26.80	27.05	1.055	1.065
J	0.127 NOM		0.005 NOM	
K	13.41	13.51	0.528	0.532
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	4.52	5.03	0.178	0.198
S	3.00	3.25	0.118	0.128
T	1.40	1.65	0.055	0.065
U	2.92	3.68	0.115	0.145

CASE 244

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	5.0 28	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

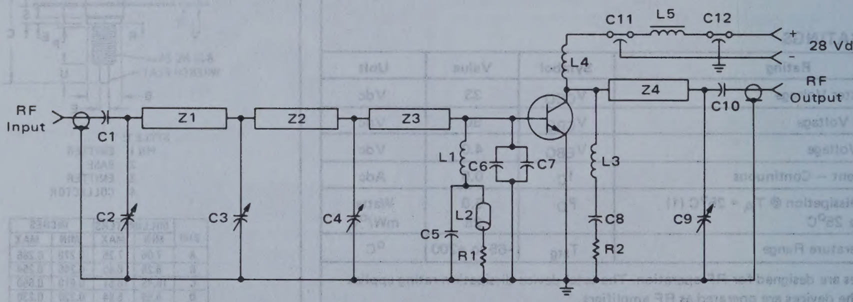
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	25	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, I_B = 0)	BV_{CEO}	33	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 20 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	100	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	–	8.0	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 2.0 W, f = 400 MHz)	G_{PE}	12	–	–	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 2.0 W, f = 400 MHz)	η	50	–	–	%

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1,C10	0.018 μF VITRAMON Chip
C2,C3,C9	1.0-10 pF JOHANSON Type 2951
C4	1.0-20 pF JOHANSON Type 3906
C5	100 pF UNDERWOOD (UNELCO)
C6,C7	5.0 pF ATC Chip
C8	0.1 μF ERIE Disc Ceramic
C11,C12	680 pF ALLEN BRADLEY Feedthru
L1	3.9 μH Molded Choke
L2	Ferrite Bead, FERROXCUBE 56-590-65-3B
L3	4 Turns, #22 AWG, 0.1″ ID

L4	6 Turns, #20 AWG, 1/8″ ID
L5	Ferrite Choke, FERROXCUBE VK200-20-4B
R1	2.7 Ohm, 1/8 Watt, 10%
R2	5.1 Ohm, 1/8 Watt, 10%
Z1,Z3	Microstrip Line, 0.1″ W x 0.5″ L
Z2	Microstrip Line, 0.1″ W x 0.4″ L
Z4	Microstrip Line, 0.075″ W x 2.5″ L

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062″

Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

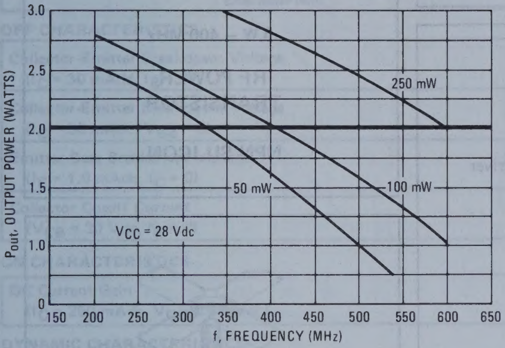


FIGURE 3 – OUTPUT POWER versus INPUT POWER

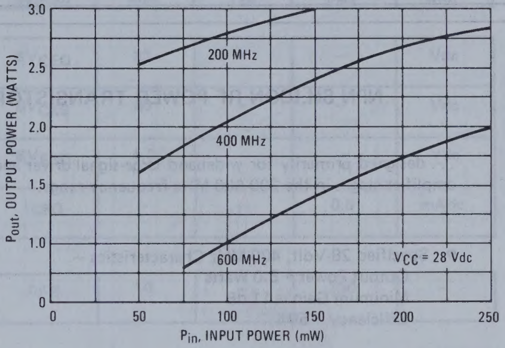


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

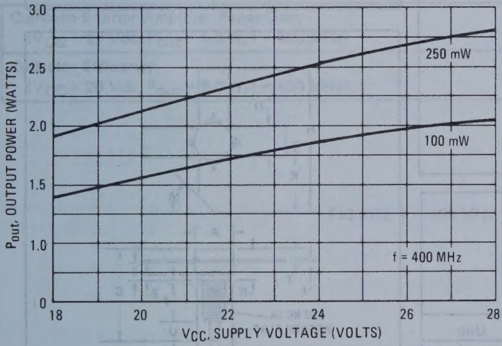
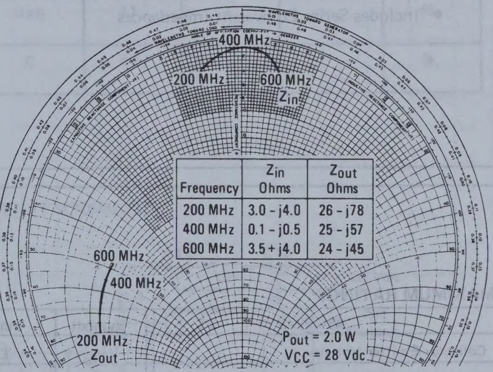
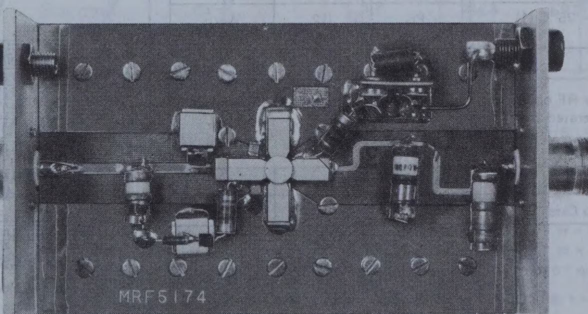


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



Frequency	Z_{in} Ohms	Z_{out} Ohms
200 MHz	3.0 - j4.0	26 - j78
400 MHz	0.1 - j0.5	25 - j57
600 MHz	3.5 + j4.0	24 - j45

FIGURE 6 – 400 MHz TEST CIRCUIT



MRF5175 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

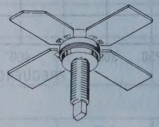
. . . designed primarily for wideband large-signal driver and predriver amplifier stages in the 200-600 MHz frequency range.

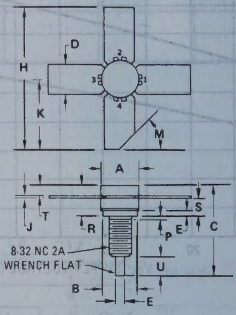
- Specified 28-Volt, 400-MHz Characteristics –
  Output Power = 5.0 Watts
  Minimum Gain = 11 dB
  Efficiency = 50%
- Characterized from 200 to 600 MHz
- Includes Series Equivalent Impedances

5 W – 400 MHz

RF POWER TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.06	7.26	0.278	0.286
B	6.25	6.45	0.246	0.254
C	15.49	16.51	0.610	0.650
D	5.59	5.84	0.220	0.230
E	1.52 NOM		0.060 NOM	
H	26.80	27.05	1.055	1.065
J	0.127 NOM		0.005 NOM	
K	13.41	13.51	0.528	0.532
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	4.52	5.03	0.178	0.198
S	3.00	3.25	0.118	0.128
T	1.40	1.65	0.055	0.065
U	2.92	3.68	0.115	0.145

CASE 244

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	12 69	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

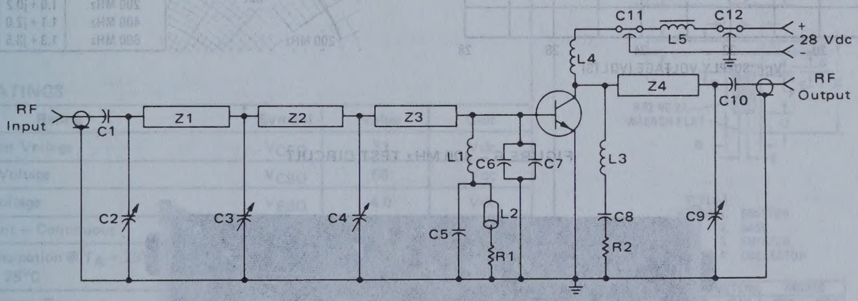
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	12	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	33	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	100	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	–	15	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain (V_{CC} = 28 Vdc, P_{out} = 5.0 W, f = 400 MHz)	G_{PE}	11	–	–	dB
Collector Efficiency (V_{CC} = 28 Vdc, P_{out} = 5.0 W, f = 400 MHz)	η	50	–	–	%

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1,C10	0.018 µF VITRAMON Chip
C2,C3,C9	1.0-10 pF JOHANSON Type 2951
C4	1.0-20 pF JOHANSON Type 3906
C5	100 pF UNDERWOOD (UNELCO)
C6,C7	5.0 pF ATC Chip
C8	0.1 µF ERIE Disc Ceramic
C11,C12	680 pF ALLEN BRADLEY Feedthru
L1	3.9 µH Molded Choke
L2	Ferrite Bead, FERROXCUBE 56-590-65-3B
L3	4 Turns, #22 AWG, 0.1″ ID
L4	6 Turns, #20 AWG, 1/8″ ID
L5	Ferrite Choke, FERROXCUBE VK200-20-4B
R1	2.7 Ohm, 1/8 Watt, 10%
R2	5.1 Ohm, 1/8 Watt, 10%
Z1,Z3	Microstrip Line, 0.1″ W x 0.5″ L
Z2	Microstrip Line, 0.1″ W x 0.4″ L
Z4	Microstrip Line, 0.075″ W x 2.5″ L

Board – Glass Teflon, ϵ_R = 2.56, t = 0.062″

Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

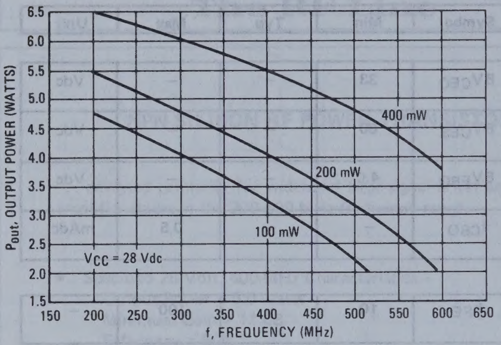


FIGURE 3 – OUTPUT POWER versus INPUT POWER

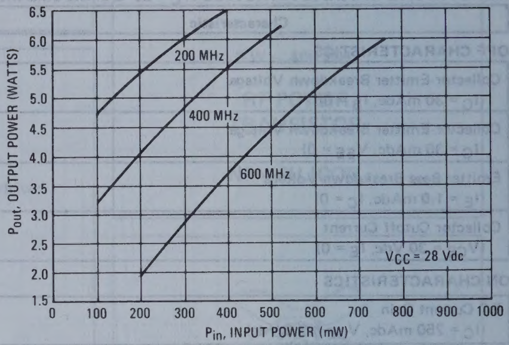


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

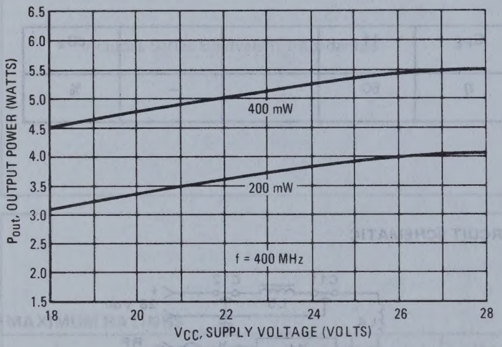
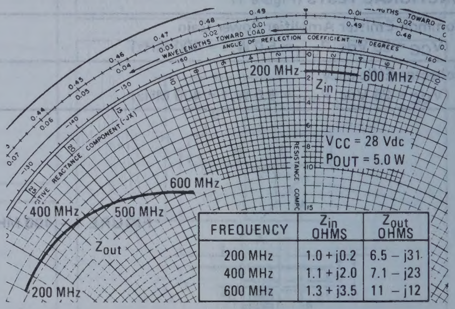
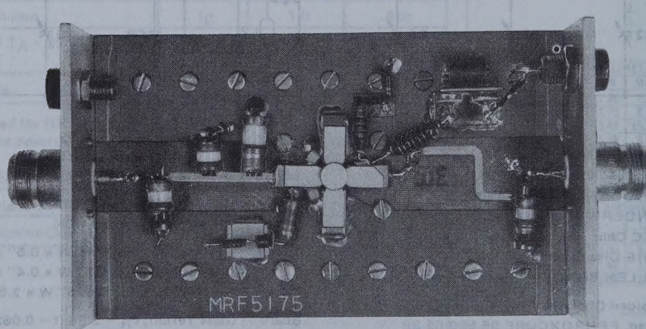


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



FREQUENCY	Z_{in} OHMS	Z_{out} OHMS
200 MHz	1.0 + j0.2	6.5 – j31
400 MHz	1.1 + j2.0	7.1 – j23
600 MHz	1.3 + j3.5	11 – j12

FIGURE 6 – 400 MHz TEST CIRCUIT



MRF5176 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

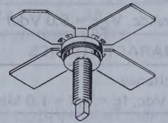
. . . designed primarily for wideband large-signal driver and predriver amplifier stages in the 200-600 MHz frequency range.

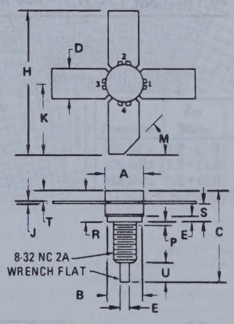
- Specified 28 Volt, 400 MHz Characteristics –
  Output Power = 15 Watts
  Minimum Gain = 10 dB
  Efficiency = 50%
- Characterized from 200 to 600 MHz
- Includes Series Equivalent Impedances

15 W – 400 MHz

RF POWER
TRANSISTOR

NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. EMITTER
4. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.06	7.26	0.278	0.286
B	6.25	6.45	0.246	0.254
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D	5.59	5.84	0.220	0.230
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J	0.127 NOM		0.005 NOM	
K	13.41	13.51	0.528	0.532
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
R	4.52	5.03	0.178	0.198
S	3.00	3.25	0.118	0.128
T	1.40	1.65	0.055	0.065
U	2.92	3.68	0.115	0.145

CASE 244

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	33	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	30 170	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1) These devices are designed for RF operation. The total device dissipation rating applies only when the devices are operated as RF amplifiers.

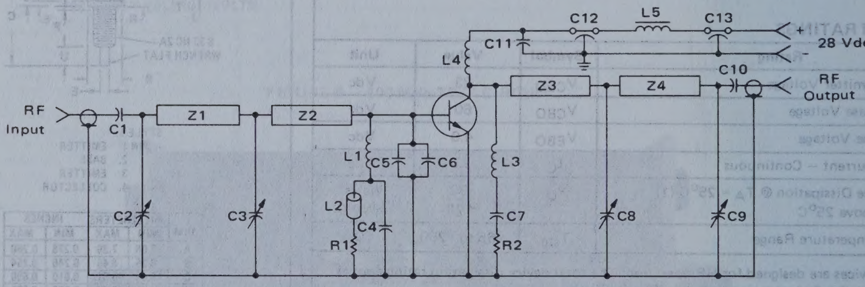
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	6.0	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 50$ mAdc, $I_B = 0$)	BV_{CEO}	33	–	–	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 50$ mAdc, $V_{BE} = 0$)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 2.0$ mAdc, $I_C = 0$)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 500$ mAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	10	–	100	–
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, f = 1.0 MHz)	C_{ob}	–	–	25	pF
FUNCTIONAL TESTS (Figure 1)					
Common-Emitter Amplifier Power Gain ($V_{CC} = 28$ Vdc, $P_{out} = 15$ W, f = 400 MHz)	G_{PE}	10	–	–	dB
Collector Efficiency ($V_{CC} = 28$ Vdc, $P_{out} = 15$ W, f = 400 MHz)	η	50	–	–	%

FIGURE 1 – 400 MHz TEST CIRCUIT SCHEMATIC



C1,C10	0.018 µF VITRAMON Chip
C2,C3,C8	1.0-20 pF JOHANSON Type 3906
C4	100 pF UNDERWOOD (UNELCO)
C5,C6	56 pF ATC Chip
C7	0.1 µF ERIE Disc Ceramic
C9	1.0-20 pF JOHANSON Type 3906
C11	1.0 µF, 35 V TANTALUM
C12,C13	680 pF ALLEN BRADLEY Feedthru

L1	3.9 µH Molded Choke
L2	Ferrite Bead, FERROXCUBE, 56-590-65-3B
L3	3 Turns, #20 AWG, 0.1″ ID
L4	6 Turns, #20 AWG, 1/4″ ID
L5	Ferrite Choke, FERROXCUBE, VK200-20-4B

R1	207 Ω, 1/8 W, 10%
R2	5.1 Ω, 1/8 W, 10%
Z1	Microstrip Line, 0.1″ W x 1.2″ L
Z2	Microstrip Line, 0.25″ W x 0.7″ L
Z3,Z4	Microstrip Line, 0.075″ W x 1.25″ L

Board – Glass Teflon, $\epsilon_R = 2.56$, t = 0.062″

Input/Output Connectors – Type N

FIGURE 2 – OUTPUT POWER versus FREQUENCY

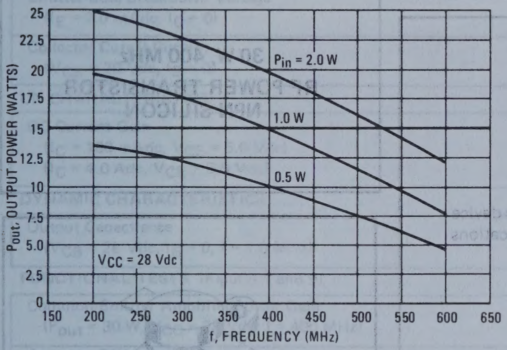


FIGURE 3 – OUTPUT POWER versus INPUT POWER

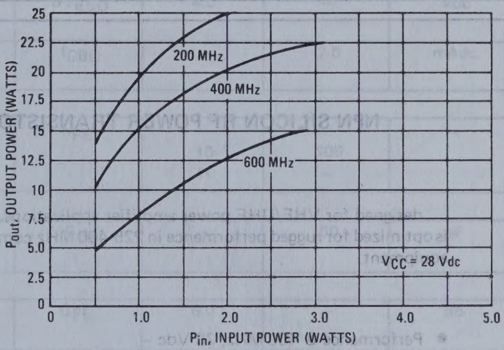


FIGURE 4 – OUTPUT POWER versus SUPPLY VOLTAGE

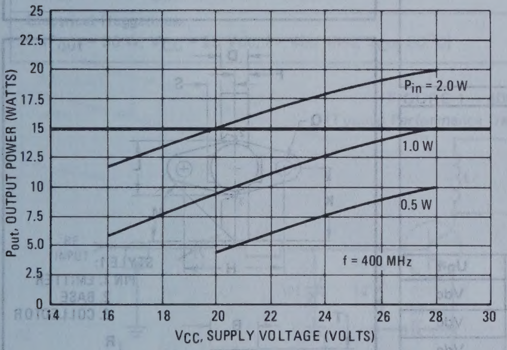
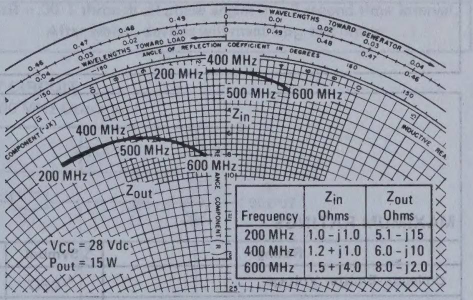
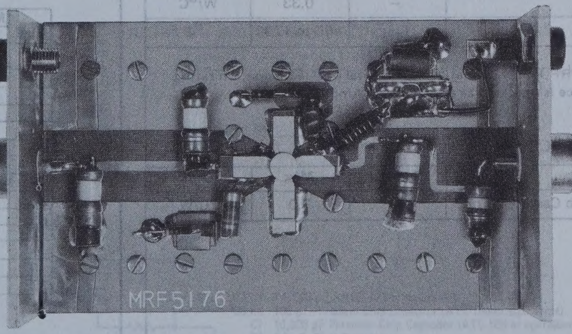


FIGURE 5 – SERIES EQUIVALENT IMPEDANCE



Frequency	Z_{in} Ohms	Z_{out} Ohms
200 MHz	1.0 - j1.0	5.1 - j15
400 MHz	1.2 + j1.0	6.0 - j10
600 MHz	1.5 + j4.0	8.0 - j2.0

FIGURE 6 – 400 MHz TEST CIRCUIT



MRF5177 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF/UHF power amplifier applications. This device is optimized for rugged performance in 225-400 MHz communications equipment.

- Performance @ 400 MHz, 28 Vdc –
  Power Output = 30 W (Min)
  Gain = 6.0 dB (Min)
- Isothermal Design for Rugged Performance –
  Tested at 30:1 VSWR through all phase angles

MAXIMUM RATINGS

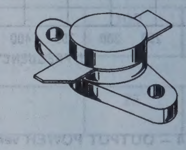
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	4.0	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ T_C = 25°C) (1) Derate Above 25°C	P_D –	58 0.33	Watts W/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

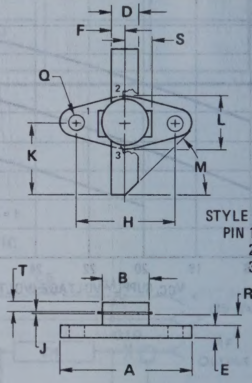
(1) This device is designed for RF Power operation. The total device dissipation rating applies only when the device is operated as a Class C RF Amplifier.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.0	°C/W

30 W, 400 MHz
RF POWER TRANSISTOR
NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

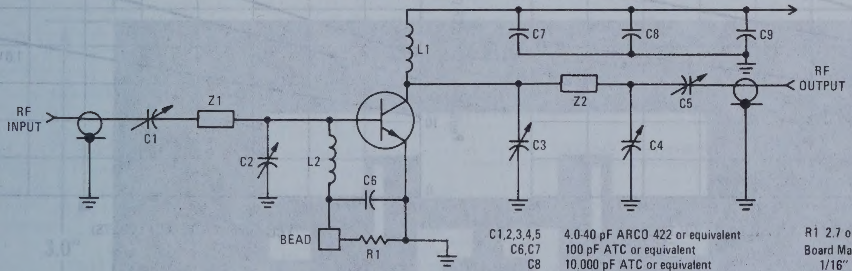
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	21.08	21.59	0.830	0.850
B	9.27	9.78	0.365	0.385
D	5.59	5.84	0.220	0.230
E	2.03	2.41	0.080	0.095
F	2.79	2.92	0.110	0.115
H	15.11	15.37	0.595	0.605
J	0.10	0.15	0.004	0.006
K	13.08	13.59	0.515	0.535
L	9.91	10.41	0.390	0.410
M	45°	NOM	45°	NOM
Q	2.92	3.18	0.115	0.125
R	1.52	2.03	0.060	0.080
S	–	5.38	–	0.212
T	2.03	2.54	0.080	0.100

CASE 215

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	35	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		10	100	
(I_C = 4.0 Adc, V_{CE} = 5.0 Vdc)		10	–	
DYNAMIC CHARACTERISTICS				
Output Capactiance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	50	pF
FUNCTIONAL TESTS (Figures 1 and 9)				
Common-Emitter Amplifier Power Gain (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz)	G_{PE}	6.0	–	dB
Collector Efficiency (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz)	η	60	–	%
Saturated Power (P_{in} = 11 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{sat}	36	–	Watts
Electrical Ruggedness (P_{out} = 30 W, V_{CC} = 28 Vdc, f = 400 MHz, $T_C \leq$ 50°C)	VSWR > 30:1 through all phase angles in a 3 second time interval, After which, devices will meet G_{PE} test limits.			

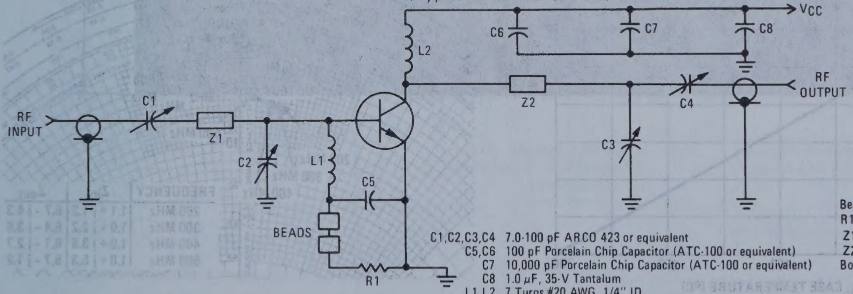
FIGURE 1 – 400 MHz TEST CIRCUIT
(Typical Performance Data for 300-500 MHz Operation)



C1,2,3,4,5	4.0-40 pF ARCO 422 or equivalent
C6,C7	100 pF ATC or equivalent
C8	10,000 pF ATC or equivalent
C9	1.0 μF, 35 V Tantalum
L1,L2	4 Turns, #20 AWG, 1/4" ID
L3	Ferrite Bead, Ferroxcube 56-590-65/3B

R1 2.7 ohms, 1/4 W, Carbon
Board Material:
1/16" Teflon Fiberglass
1 oz. copper, two-sided
Z1 0.3" Width, x 2.7" Length
Z2 0.3" Width, x 2.7" Length

FIGURE 2 – 200-300 MHz TEST CIRCUIT
(Typical Performance Data)



C1,C2,C3,C4	7.0-100 pF ARCO 423 or equivalent
C5,C6	100 pF Porcelain Chip Capacitor (ATC-100 or equivalent)
C7	10,000 pF Porcelain Chip Capacitor (ATC-100 or equivalent)
C8	1.0 μF, 35-V Tantalum
L1,L2	7 Turns #20 AWG, 1/4" ID

Beads, Ferroxcube 56-590 65/3B
R1 2.7 ohms, 1/2 W, Carbon
Z1 0.3" Width x 3.31" Length
Z2 0.3" Width x 4.53" Length
Board Material:
1/16" Glass-Teflon
1 oz. Copper, 2-sided

FIGURE 3 – OUTPUT POWER versus FREQUENCY

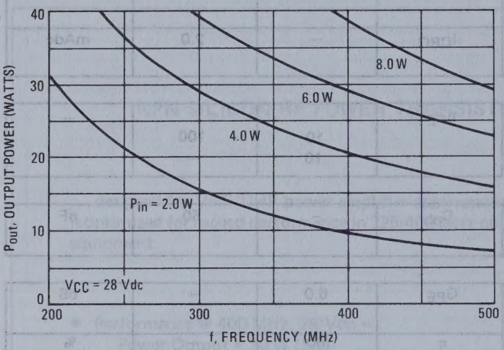


FIGURE 4 – OUTPUT POWER versus INPUT POWER

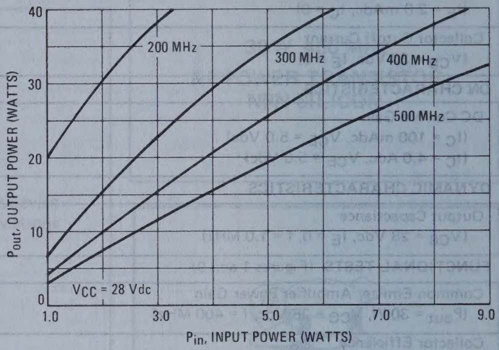


FIGURE 5 – OUTPUT POWER versus SUPPLY VOLTAGE

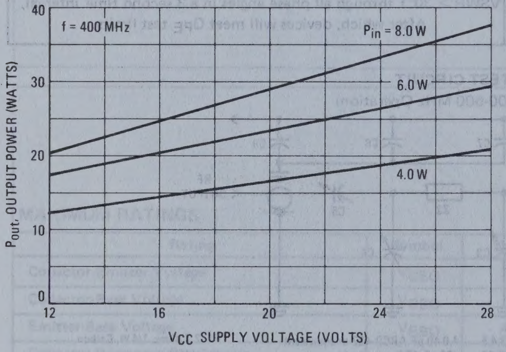


FIGURE 6 – OUTPUT POWER versus SUPPLY VOLTAGE

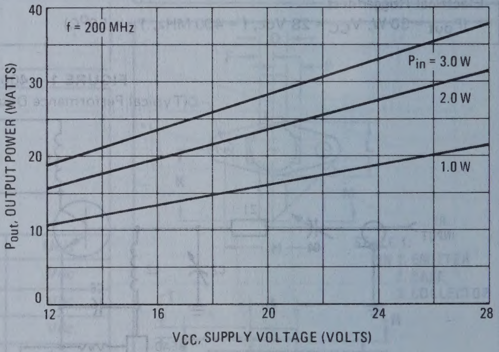


FIGURE 7 RF POWER DERATING

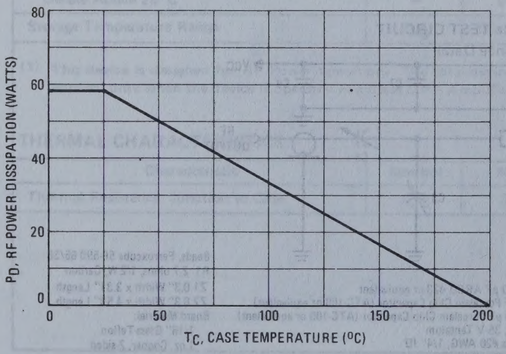
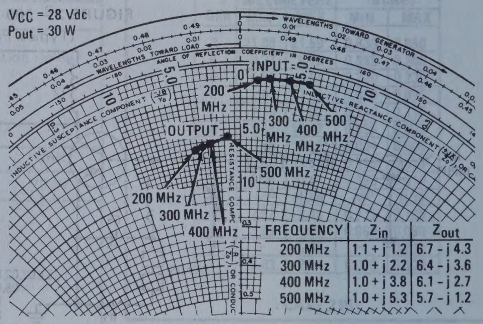
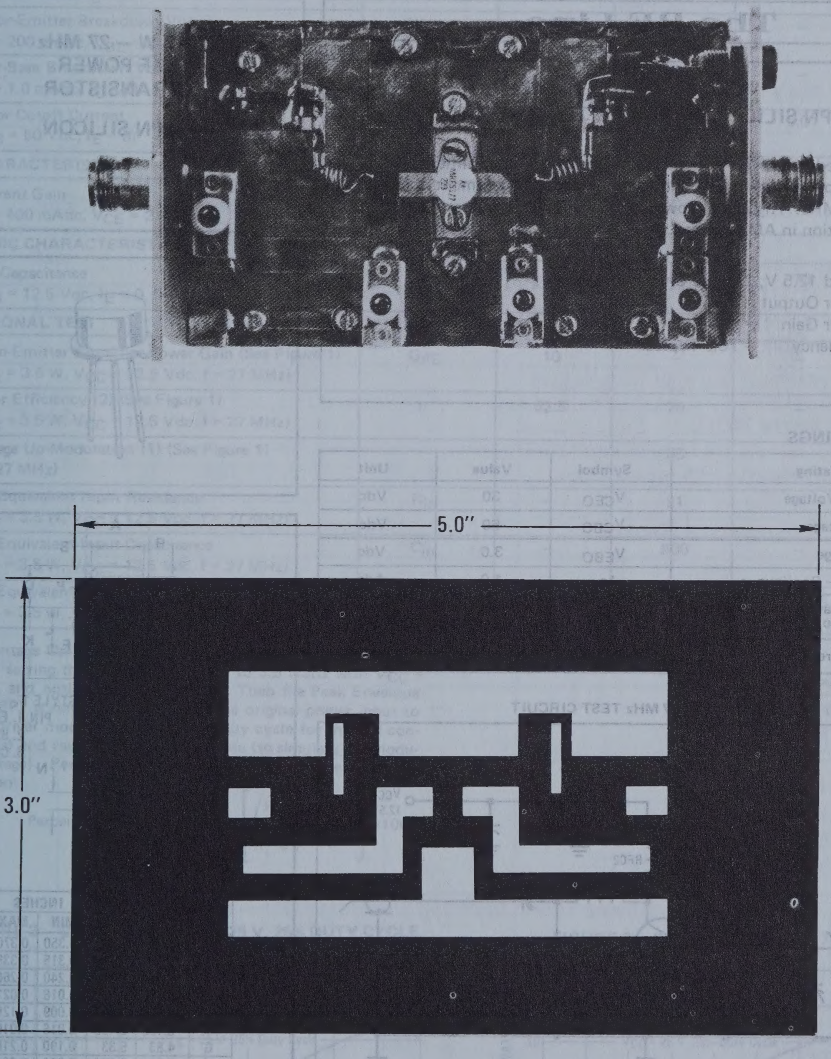


FIGURE 8 – SERIES EQUIVALENT IMPEDANCE



FREQUENCY	Z_{in}	Z_{out}
200 MHz	1.1 + j 1.2	6.7 - j 4.3
300 MHz	1.0 + j 2.2	6.4 - j 3.6
400 MHz	1.0 + j 3.8	6.1 - j 2.7
500 MHz	1.0 + j 5.3	5.7 - j 1.2

FIGURE 9 – 400 MHz CIRCUIT LAYOUT



MRF8004 (SILICON)

The RF Line

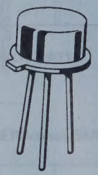
NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large-signal output amplifier stages. Intended for use in Citizen-Band communications equipment operating to 30 MHz. High breakdown voltages allow a high percentage of up-modulation in AM circuits.

- Specified 12.5 V, 27 MHz Characterisitcs –
  Power Output = 3.5 W
  Power Gain = 10 dB
  Efficiency = 70% Typical

3.5 W – 27 MHz
RF POWER
TRANSISTOR

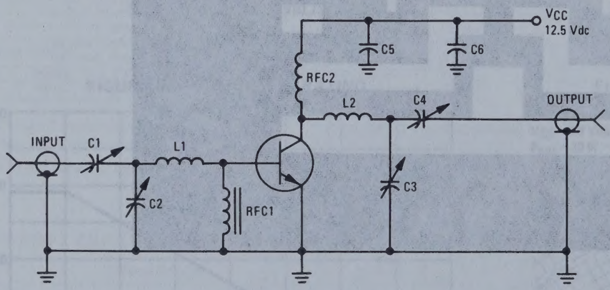
NPN SILICON



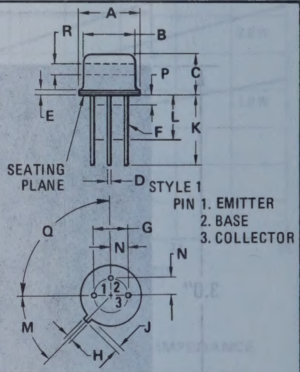
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CBO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C (1) Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – 27 MHz TEST CIRCUIT



C1, C2	9.0-180 pF ARCO 463 or Equivalent
C3, C4	5.0-80 pF ARCO 462 or Equivalent
C5	0.02 μF Ceramic Disc
C6	0.1 μF Ceramic Disc
RFC1	4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B
RFC2	26 Turns #22 Enameled Wire (2 Layers – 13 Turns Each Layer) ¼" Inner Diameter
L1	0.22 μH Molded Choke
L2	0.68 μH Molded Choke



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

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(1) This device is designed for RF operation. The total device dissipation rating applies only when the device is operated as an RF amplifier.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	30	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	—	0.01	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 400 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	10	—	—	—
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	35	70	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	G_{PE}	10	—	—	dB
Collector Efficiency (2) (See Figure 1) (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	η	62.5	70	—	%
Percentage Up-Modulation (1) (See Figure 1) (f = 27 MHz)	—	—	85	—	%
Parallel Equivalent Input Resistance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	R_{in}	—	21	—	Ohms
Parallel Equivalent Input Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{in}	—	900	—	pF
Parallel Equivalent Output Capacitance (P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 27 MHz)	C_{out}	—	200	—	pF

(1) Percentage Up-Modulation is measured in the test circuit (Figure 1) by setting the Carrier Power (P_c) to 3.5 Watts with V_{CC} = 12.5 Vdc and noting the power input. Then the Peak Envelope Power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage Up-Modulation is then determined by the relation:

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_c}\right)^{1/2} - 1\right] \bullet 100$$

(2) $$\eta = \frac{R_F\ P_{out}}{(V_{CC})\ (I_C)} \bullet 100$$

FIGURE 2 – CIRCUIT TUNED AT 25 V, 25% DUTY CYCLE, P_{out} = 15 W PEAK

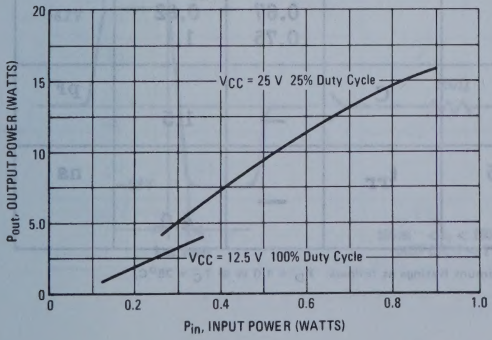
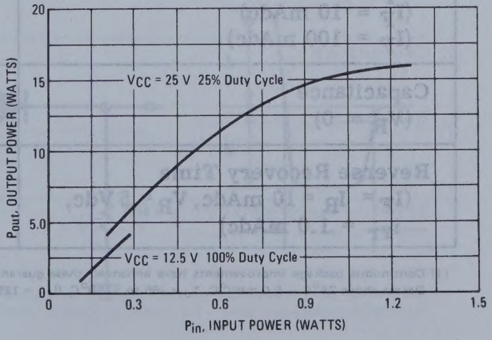
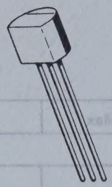


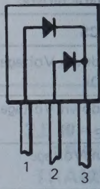
FIGURE 3 – CIRCUIT TUNED AT 12.5 V, P_{out} = 4 W



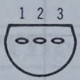
MSD6100 (SILICON)



Silicon epitaxial dual switching diode, designed for use in high speed switching applications, features high breakdown voltage, low capacitance and space saving common-cathode configuration.



CASE 29
(TO-92)



STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature	T_J (1)	135	°C
Storage Temperature Range	T_{stg} (1)	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	—	$V_{(BR)}$	100	—	Vdc
Reverse Current (V_R = 100 Vdc) (V_R = 50 Vdc) (V_R = 50 Vdc, T_A = 125°C)	2	I_R	— — —	5.0 0.1 20	μAdc
Forward Voltage (I_F = 1 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	1	V_F	0.55 0.67 0.75	0.7 0.82 1.1	Vdc
Capacitance (V_R = 0)	3	C	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	4,5	t_{rr}	—	4.0	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — FORWARD CHARACTERISTICS

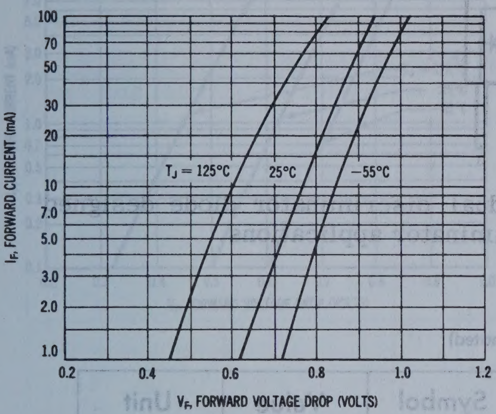


FIGURE 2 — REVERSE LEAKAGE CURRENT

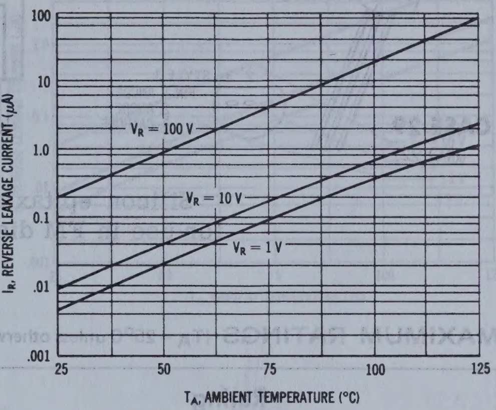


FIGURE 3 — CAPACITANCE

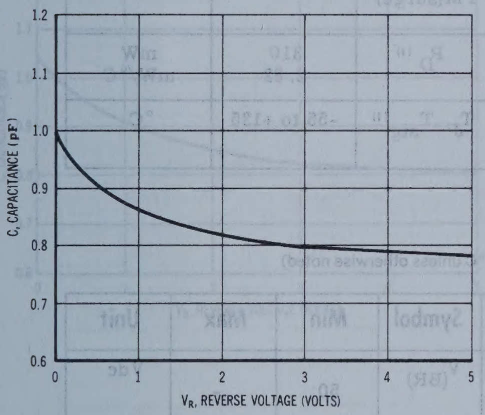


FIGURE 4 — REVERSE RECOVERY TIME

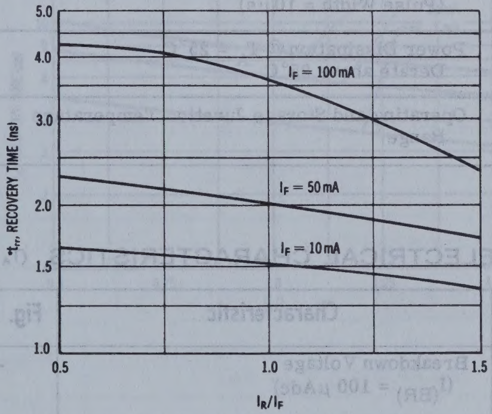
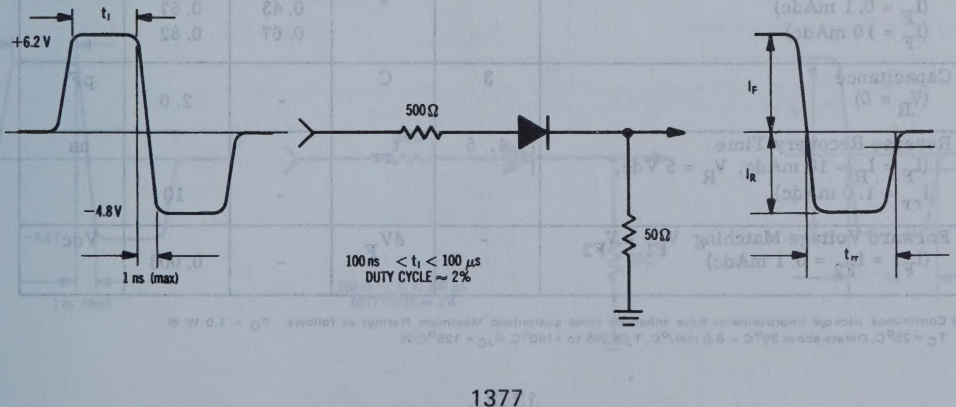
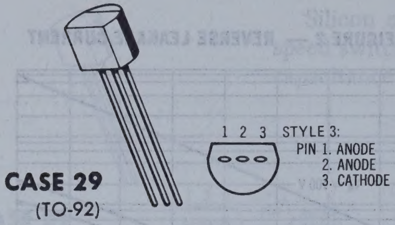


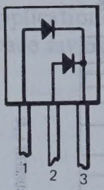
FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT


t_I
+6.2 V
−4.8 V
1 ns (max)
500Ω
100 ns < t_I < 100 µs
DUTY CYCLE ≈ 2%
50Ω
I_F
I_R
t_{rr}

MSD6101 (SILICON)



CASE 29
(TO-92)



Silicon epitaxial dual discriminator diode designed for use in FM discriminator applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	-	$V_{(BR)}$	50	-	Vdc
Reverse Current (V_R = 40 Vdc) (V_R = 40 Vdc, T_A = 125°C)	2	I_R	- -	0.1 100	μAdc
Forward Voltage (I_F = 0.1 mAdc) (I_F = 10 mAdc)	1	V_F	0.43 0.67	0.57 0.82	Vdc
Capacitance (V_R = 0)	3	C	-	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	4, 5	t_{rr}	-	10	ns
Forward Voltage Matching V_{F1} - V_{F2} (I_{F1} = I_{F2} = 0.1 mAdc)	-	ΔV_F	-	0.003	Vdc

---

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

FIGURE 1 — FORWARD CHARACTERISTICS

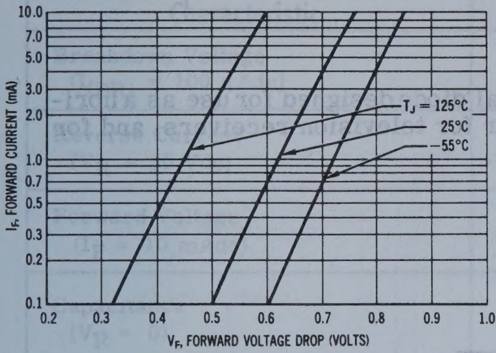


FIGURE 2 — REVERSE LEAKAGE CURRENT

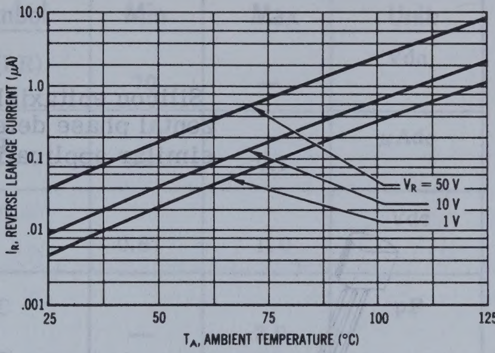


FIGURE 3 — CAPACITANCE

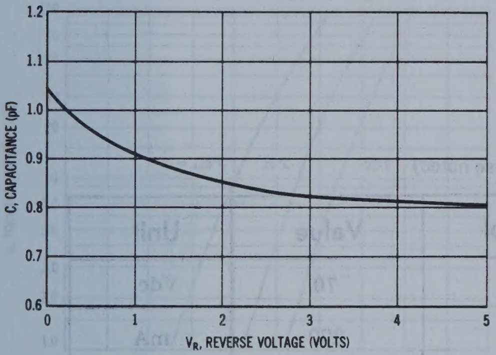


FIGURE 4 — REVERSE RECOVERY TIME

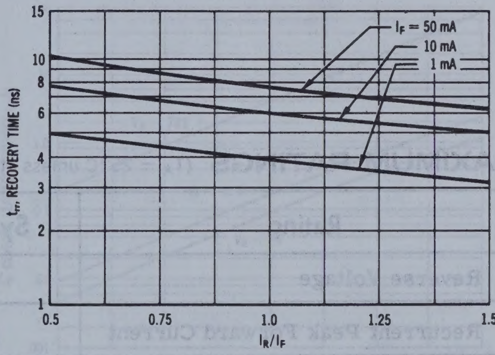
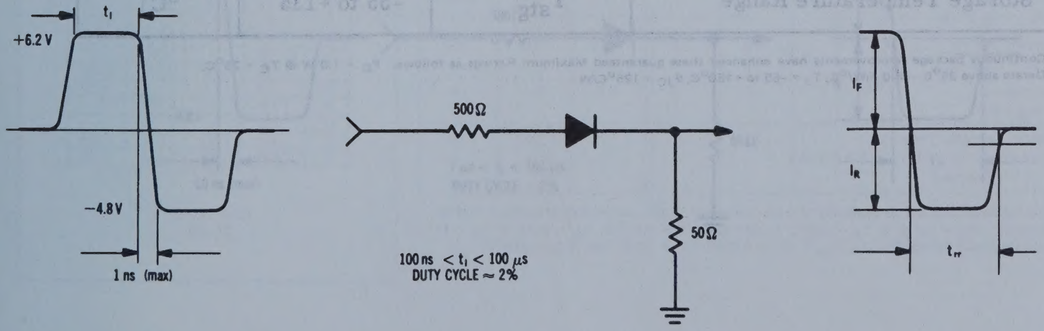
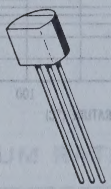


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT

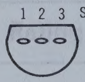

t_i
+6.2 V
−4.8 V
1 ns (max)
500 Ω
50 Ω
100 ns < t_i < 100 μs
DUTY CYCLE ≈ 2%
I_F
I_R
t_rr

MSD6102 (SILICON)

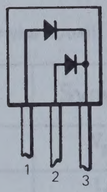
Silicon epitaxial dual diode designed for use as a horizontal phase detector for television receivers, and for similar applications.



CASE 29
(TO-92)



STYLE 3:
PIN 1. ANODE
2. ANODE
3. CATHODE



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating Junction Temperature	T_J (1)	135	°C
Storage Temperature Range	T_{stg} (1)	-55 to +135	°C

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_C = 25°C, Derate above 25°C – 8.0 mW/°C, T_J = -65 to +150°C, θ_{JC} = 125°C/W.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	0.67	1.0	Vdc
Capacitance (V_R = 0)	C	—	3.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	100	ns

FIGURE 1 — FORWARD CHARACTERISTICS

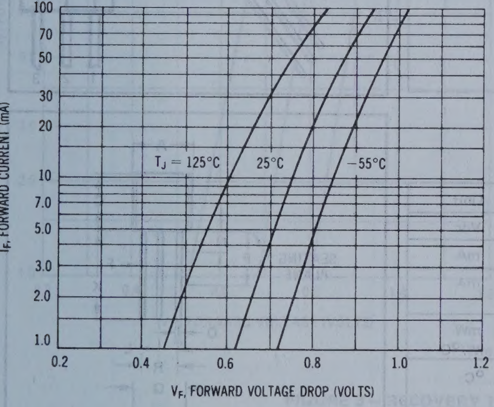


FIGURE 2 — REVERSE LEAKAGE CURRENT versus TEMPERATURE

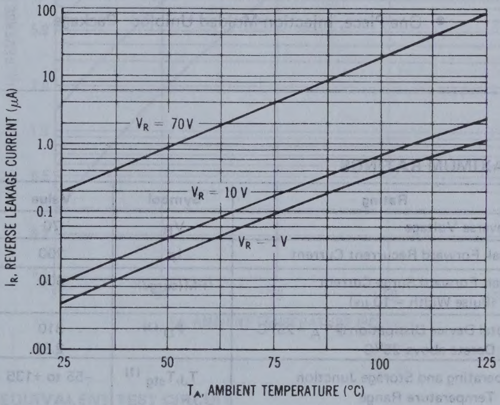
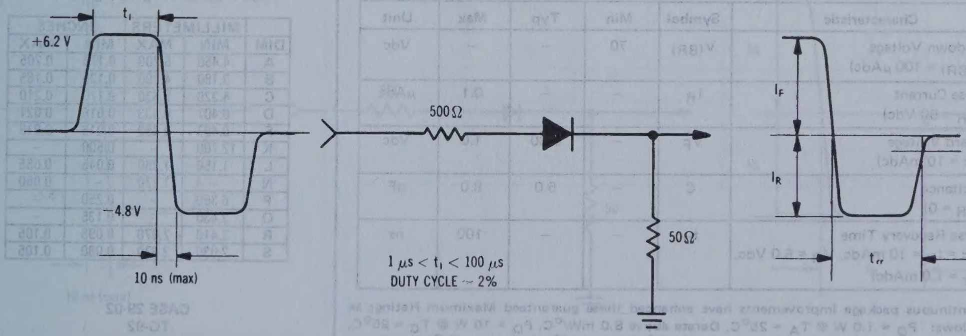


FIGURE 3 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



t_r
+6.2 V
−4.8 V
10 ns (max)
500 Ω
50 Ω
1 μs < t_r < 100 μs
DUTY CYCLE ~ 2%
I_F
I_R
t_{rr}

MSD6150 (SILICON)

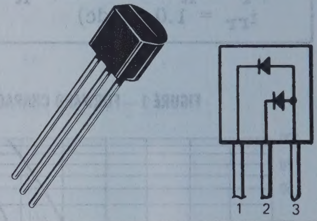
SILICON EPITAXIAL DUAL DIODE

. . . designed for general-purpose consumer applications.

- High Breakdown Voltage –
  $V_{(BR)}$ = 70 Vdc (Min) @ $I_{(BR)}$ = 100 µAdc
- Space-Saving Package with Common Anode Configuration
- One-Piece, Injection-Molded Unibloc Package

SILICON EPITAXIAL
DUAL DIODE

COMMON ANODE



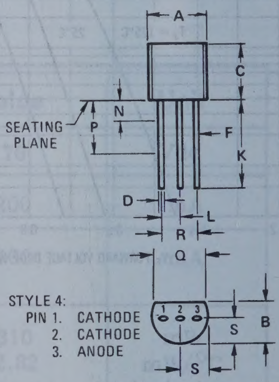
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 µs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D (1)	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} (1)	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 µAdc)	$V_{(BR)}$	70	–	–	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	–	–	0.1	µAdc
Forward Voltage (I_F = 10 mAdc)	V_F	–	0.80	1.0	Vdc
Capacitance (V_R = 0)	C	–	5.0	8.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	–	100	ns

(1) Continuous package improvements have enhanced these guaranteed Maximum Ratings as follows: P_D = 1.0 W @ T_A = 25°C, Derate above 8.0 mW/°C, P_D = 10 W @ T_C = 25°C, Derate above 80 mW/°C, T_J, T_{stg} = -55 to +150°, θ_{JC} = 12.5°C/W, θ_{JA} = 125°C.



STYLE 4:
PIN 1. CATHODE
2. CATHODE
3. ANODE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

FIGURE 1 – FORWARD CHARACTERISTICS

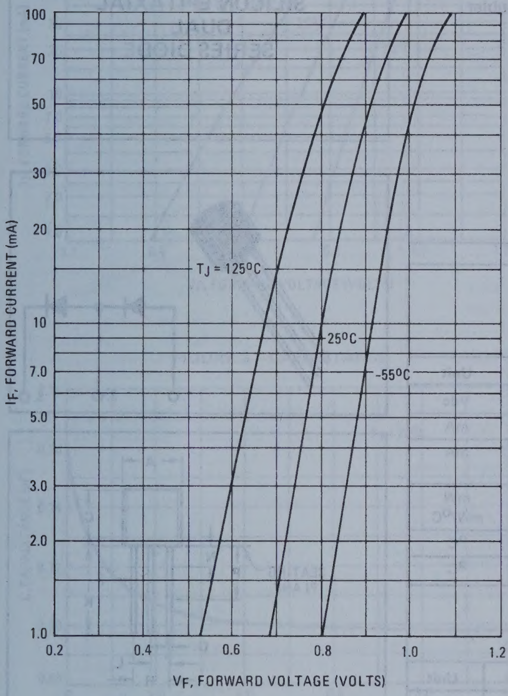


FIGURE 2 – REVERSE LEAKAGE CURRENT

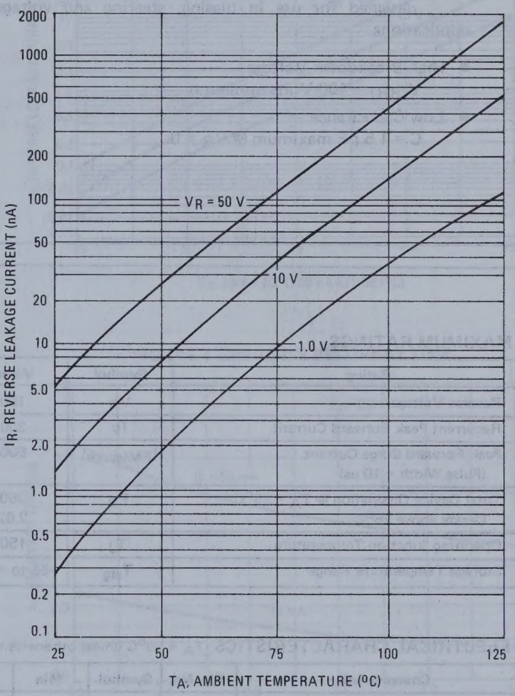
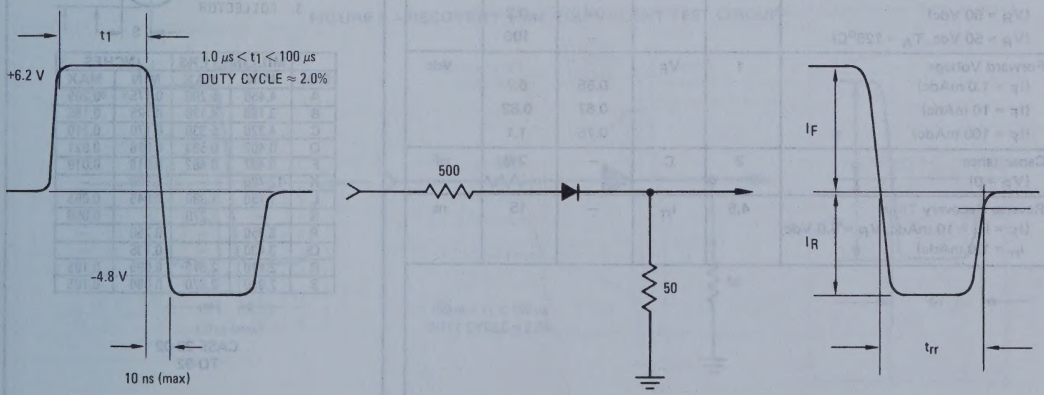


FIGURE 3 – RECOVERY TIME EQUIVALENT TEST CIRCUIT



t_1
+6.2 V
1.0 μs < t_1 < 100 μs
DUTY CYCLE ≈ 2.0%
-4.8 V
10 ns (max)
500
50
I_F
I_R
t_{rr}

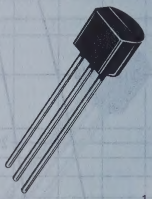
MSD7000 (SILICON)

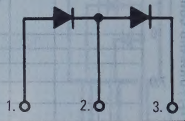
SILICON EPITAXIAL DUAL SERIES DIODE

. . . designed for use in biasing, steering and voltage doubler applications.

- High Breakdown Voltage —
  $V_{(BR)}$ = 100 Volts minimum
- Low Capacitance —
  C = 1.5 pF maximum @ V_R = 0

SILICON EPITAXIAL DUAL SERIES DIODE



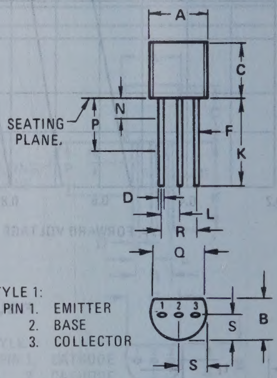


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 µs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.82	mW mW/°C
Operating Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 µAdc)	–	$V_{(BR)}$	100	–	Vdc
Reverse Current	2	I_R			µAdc
(V_R = 100 Vdc)			–	0.5	
(V_R = 50 Vdc)			–	0.2	
(V_R = 50 Vdc, T_A = 125°C)			–	100	
Forward Voltage	1	V_F			Vdc
(I_F = 1.0 mAdc)			0.55	0.7	
(I_F = 10 mAdc)			0.67	0.82	
(I_F = 100 mAdc)			0.75	1.1	
Capacitance (V_R = 0)	3	C	–	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	4,5	t_{rr}	–	15	ns



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

FIGURE 1 – FORWARD CHARACTERISTICS

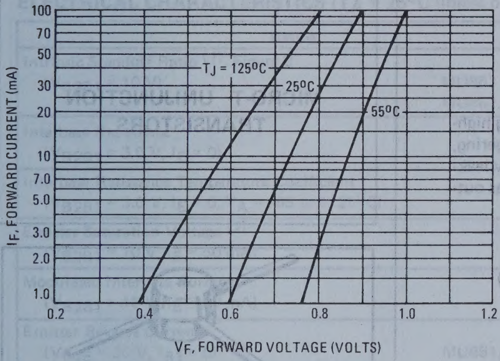


FIGURE 2 – REVERSE LEAKAGE CURRENT

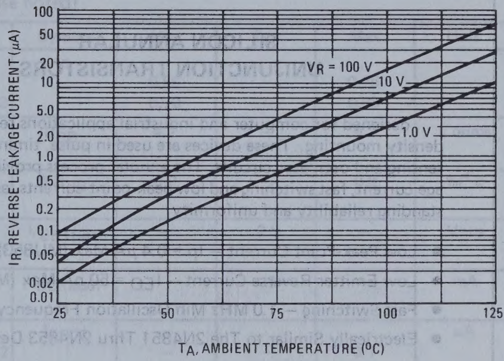


FIGURE 3 – CAPACITANCE

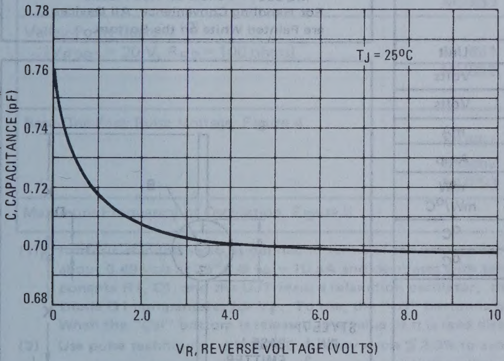


FIGURE 4 – REVERSE RECOVERY TIME

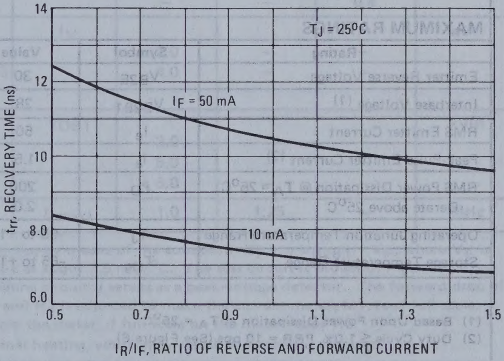
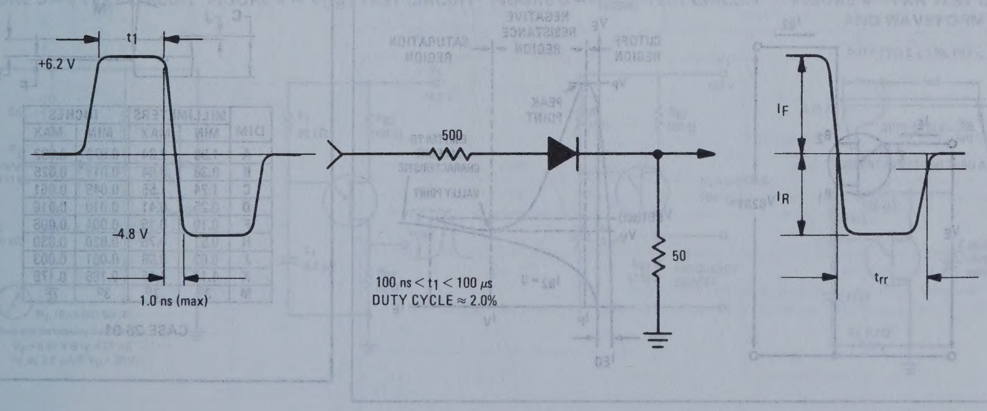


FIGURE 5 – RECOVERY TIME EQUIVALENT TEST CIRCUIT


t1
+6.2 V
-4.8 V
1.0 ns (max)
500
50
100 ns < t1 < 100 µs
DUTY CYCLE ≈ 2.0%
I_F
I_R
t_rr

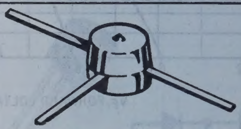
MU851 (SILICON)
thru
MU853

SILICON ANNULAR UNIJUNCTION TRANSISTORS

. . . designed for computer and industrial applications requiring high-density mounting. These devices are used in pulse, timing, triggering, sensing and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents, as well as outstanding reliability and uniformity.

- Low Peak-Point Current – $I_P = 0.4\ \mu A$ Max (MU853)
- Low Emitter Reverse Current – $I_{EO} = 50$ nA Max (MU853)
- Fast Switching – 1.0 MHz Min Oscillation Frequency
- Electrically Similar to The 2N4851 Thru 2N4853 Devices

MICRO-T UNIJUNCTION TRANSISTORS

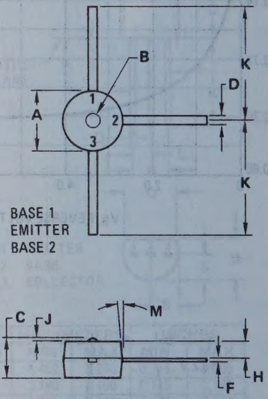


UNIT IDENTITY COLOR CODING
MU851 – Red Plastic
MU852 – Black on Red Plastic
MU853 – Yellow on Red Plastic
For Handling Convenience, All Devices are Painted White on the Bottom.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage (1)	V_{B2B1}	28	Volts
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current (2)	i_e	1.5	Amp
RMS Power Dissipation @ $T_A = 25^\circ C$ Derate above $25^\circ C$	P_D	200 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Based Upon Power Dissipation at $T_A = 25^\circ C$
(2) Duty Cycle ≦ 1.0%, PRR = 10 pps (See Figure 6)



STYLE 7:
PIN 1. BASE 1
2. EMITTER
3. BASE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	1.98	2.34	0.078	0.092
B	0.38	0.64	0.015	0.025
C	1.24	1.55	0.049	0.061
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
M	3°	7°	3°	7°

CASE 28-01

FIGURE 1 – UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

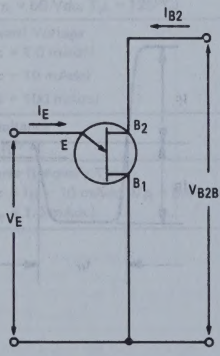
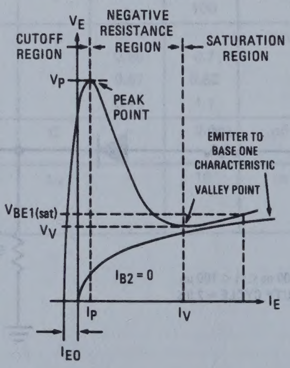


FIGURE 2 – STATIC EMITTER CHARACTERISTICS CURVES



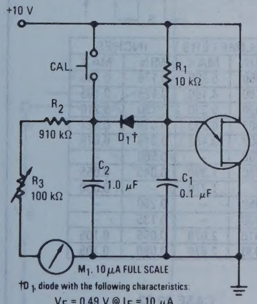
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Rating		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (1), Figure 3		η				–
(V_{B2B1} = 10 V)	MU851		0.56	–	0.75	
	MU852, MU853		0.70	–	0.85	
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		R_{BB}	4.7	–	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65 to +125°C)		αR_{BB}	0.2	–	0.8	%/°C
Emitter Saturation Voltage (2) (V_{B2B1} = 10 V, I_E = 50 mA)		$V_{EB1(sat)}$	–	2.5	–	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	–	20	–	mA
Emitter Reverse Current		I_{EB2O}				μA
(V_{B2E} = 30 V, I_{B1} = 0)	MU851, MU852		–	–	0.1	
	MU853		–	–	0.05	
Peak-Point Emitter Current		I_P				μA
(V_{B2B1} = 25 V)	MU851, MU852		–	–	2.0	
	MU853		–	–	0.4	
Valley-Point Current (2)		I_V				mA
(V_{B2B1} = 20 V, R_{B2} = 100 ohms)	MU851		2.0	–	–	
	MU852, MU853		4.0	–	–	
Base-One Peak Pulse Voltage, Figure 4		V_{OB1}				Volts
	MU851		3.0	–	–	
	MU852		5.0	–	–	
	MU853		6.0	–	–	
Maximum Frequency of Oscillation, Figure 5		$f_{(max)}$	1.0	1.25	–	MHz

(1) η, Intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C @ I_F = 10 μA and decreases with temperature at about 2.5 mV/°C. The test circuit is shown in Figure 3. Components R1, C1, and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D1 compensates for V_F. To use, the "cal" button is pushed, and R3 is adjusted to make the current meter, M1, read full scale. When the "Cal" bottom is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

(2) Use pulse techniques: PW ≈ 300 μs, duty cycle ≦ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 – η TEST CIRCUIT


+10 V
CAL.
R1
10 kΩ
R2
910 kΩ
D1†
C2
1.0 μF
C1
0.1 μF
R3
100 kΩ
M1, 10 μA FULL SCALE

†D1, diode with the following characteristics:
V_F = 0.49 V @ I_F = 10 μA
$I_R \leq$ 2.0 μA @ V_R = 20 V

FIGURE 4 – V_{OB1} TEST CIRCUIT

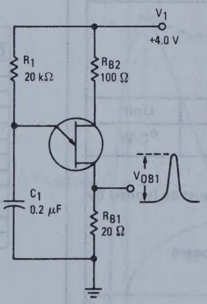

V1
+4.0 V
R1
20 kΩ
RB2
100 Ω
VOB1
C1
0.2 μF
RB1
20 Ω

FIGURE 5 – $f_{(max)}$ TEST CIRCUIT

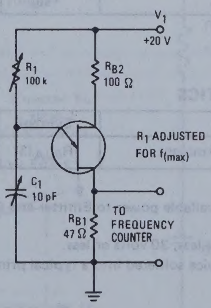
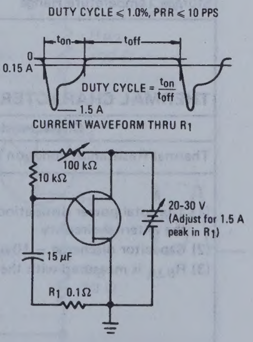

V1
+20 V
R1
100 k
RB2
100 Ω
R1 ADJUSTED FOR f(max)
C1
10 pF
RB1
47 Ω
TO FREQUENCY COUNTER

FIGURE 6 – PRR TEST CIRCUIT AND WAVEFORM


DUTY CYCLE ≤ 1.0%, PRR ≤ 10 PPS
ton
toff
0
0.15 A
DUTY CYCLE = ton/toff
1.5 A
CURRENT WAVEFORM THRU R1
100 kΩ
10 kΩ
20-30 V (Adjust for 1.5 A peak in R1)
15 μF
R1 0.1 Ω

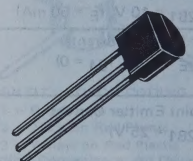
MU2646 (SILICON)

SILICON ANNULAR PN UNIJUNCTION TRANSISTOR

. . . designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits.

- Low Peak Point Current – 5.0 μA (Max)
- Low Emitter Reverse Current – 12 μA (Max)
- Passivated Surface for Reliability and Uniformity
- TO-18 Lead Form Available Upon Request

PN UNIJUNCTION TRANSISTOR



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	Value	Unit
RMS Emitter Current	$I_{E(RMS)}$	50	mA
Peak Pulse Emitter Current (2)	i_e	2.0	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
RMS Power Dissipation @ T_A = 25°C (1) Derate above 25°C	P_D	300 3.0	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

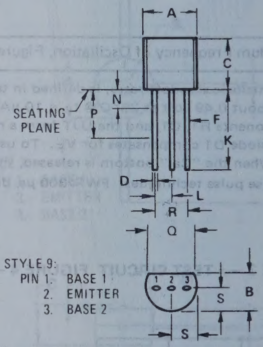
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(3)	333	°C/W

(1) The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry.

(2) Capacitor discharge – 10 μF or less, 30 volts or less.

(3) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) (Note 1)	η	0.56	–	0.75	–
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	r_{BB}	4.7	7.0	9.1	kΩ
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -55°C to +125°C)	$\alpha_{r_{BB}}$	0.1	–	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) (Note 2)	$V_{EB1(sat)}$	–	3.5	–	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)	$I_{B2(mod)}$	–	15	–	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	I_{EB2O}	–	0.005	12	µA
Peak Point Emitter Current (V_{B2B1} = 25 V)	I_P	–	1.0	5.0	µA
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) (Note 2)	I_V	4.0	6.0	–	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}	3.0	5.0	–	Volts

Notes:

(1) Intrinsic standoff ratio, η, is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage

V_{B2B1} = Interbase Voltage

$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (≈0.5 V @ 10 µA)

(2) Use pulse techniques: PW ≈ 300 µs, duty cycle ≤ 2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

(3) Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1
UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

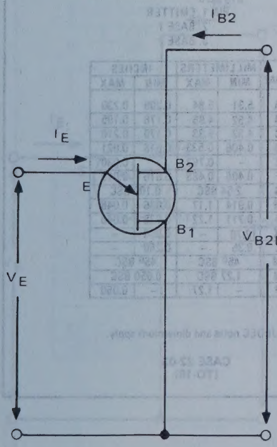


FIGURE 2
STATIC EMITTER CHARACTERISTIC CURVES
(Exaggerated to Show Details)

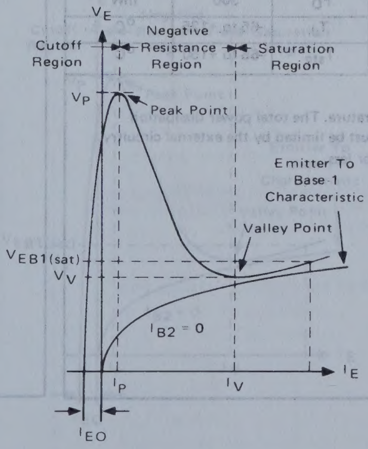
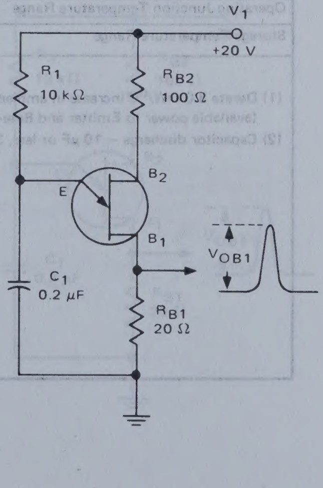


FIGURE 3 – V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)



MU2646M (SILICON)

SILICON ANNULAR PN UNIJUNCTION TRANSISTOR

. . . designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits. These devices feature:

- Low Peak Point Current – 5.0 μA (Max)
- Passivated Surface for Reliability and Uniformity

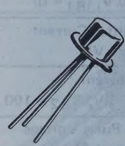
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

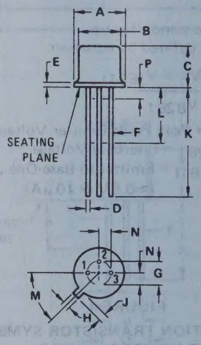
Rating	Symbol	Value	Unit
RMS Emitter Current	$I_{E(RMS)}$	50	mA
Peak Pulse Emitter Current (2)	i_e	2.0	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
Power Dissipation (1)	P_D	300	mW
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Derate 3.0 mW/°C increase in ambient temperature. The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry.

(2) Capacitor discharge – 10 μF or less, 30 volts or less.

PN UNIJUNCTION TRANSISTOR





STYLE 5:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinisic Standoff Ratio (V_{B2B1} = 10 V) (Note 1)	η	0.56	–	0.75	–
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	r_{BB}	4.7	7.0	9.1	kΩ
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -55°C to +125°C)	α_{rBB}	0.1	–	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) (Note 2)	$V_{EB1(sat)}$	–	3.5	–	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)	$I_{B2(mod)}$	–	15	–	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	I_{EB2O}	–	0.005	12	µA
Peak Point Emitter Current (V_{B2B1} = 25 V)	I_P	–	1.0	5.0	µA
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) (Note 2)	I_V	2.0	4.0	–	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}	3.0	5.0	–	Volts

Notes:

(1) Intrinsic standoff ratio, η, is defined by equation:

$$\eta = \frac{V_P - V_{EB1}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
V_{EB1} = Emitter to Base-One Junction Diode Drop ($\approx$0.5 V @ 10 µA)

(2) Use pulse techniques: PW ≈ 300 µs, duty cycle ⩽ 2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

(3) Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1

UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

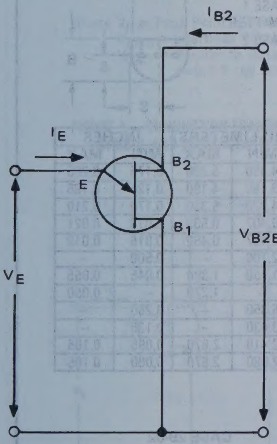


FIGURE 2

STATIC EMITTER CHARACTERISTIC CURVES

(Exaggerated to Show Details)

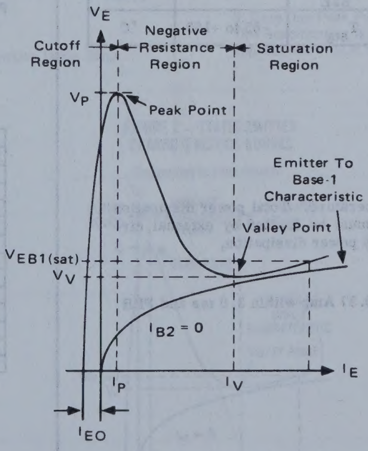
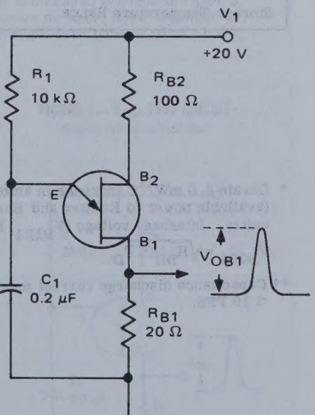


FIGURE 3 – V_{OB1} TEST CIRCUIT

(Typical Relaxation Oscillator)



MU4891 (SILICON)
thru
MU4894

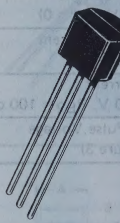
SILICON ANNULAR PLASTIC UNIJUNCTION TRANSISTORS

. . . designed for military and industrial use in pulse, timing, triggering, sensing, and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents as well as outstanding reliability and uniformity.

Recommended usage includes:

- Long-time Delay Circuits - MU4894
- Silicon Controlled Rectifier Triggering Circuits - MU4893
- High-frequency Relaxation-Oscillator Circuits - MU4892
- General-Purpose Unijunction Applications - MU4891

PN UNIJUNCTION TRANSISTORS



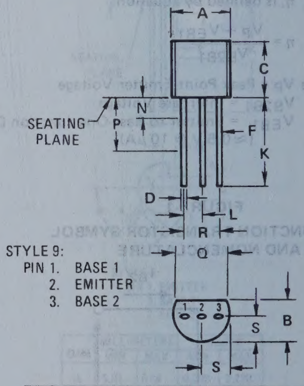
MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	300	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Storage Temperature Range	T_{stg}	-65 to +150	°C

* Derate 3.0 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry. Interbase voltage (V_{B2B1}) limited by power dissipation,

$$V_{B2B1} = \sqrt{R_{BB} \cdot P_D}$$

** Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≤ 10 PPS.



STYLE 9:
PIN 1. BASE 1
2. EMITTER
3. BASE 2

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) Note 1	η				-
MU4892		0.51	-	0.69	
MU4891, MU4893		0.55	-	0.82	
MU4894		0.74	-	0.86	
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	r_{BB}				k ohms
MU4891, MU4892		4.0	7.0	9.1	
MU4893, MU4894		4.0	7.0	12.0	
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65°C to + 100°C)	αr_{BB}	0.1	-	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) Note 2	$V_{EB1(sat)}$	-	2.5	4.0	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)	$I_{B2(mod)}$	10	15	-	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	I_{EB2O}	-	5.0	10	nA
Peak Point Emitter Current (V_{B2B1} = 25 V)	I_P				μA
MU4891			0.6	5.0	
MU4892, MU4893		-	0.6	2.0	
MU4894		-	0.6	1.0	
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) Note 2	I_V				mA
MU4891, MU4893, MU4894		2.0	4.0	-	
MU4892		2.0	3.0	-	
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}				Volts
MU4891, MU4892, MU4894		3.0	5.0	-	
MU4893		6.0	8.0	-	

NOTES

1. Intrinsic standoff ratio. η, is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (≈0.5 V @ 10 μA)

2. Use pulse techniques: PW ~ 300 μs duty cycle ≤2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

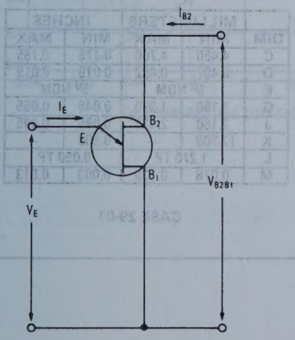


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

(Exaggerated to Show Details)

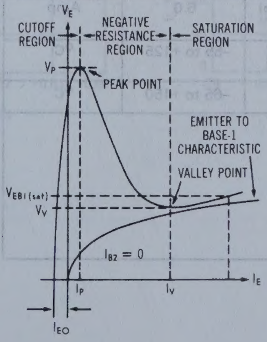
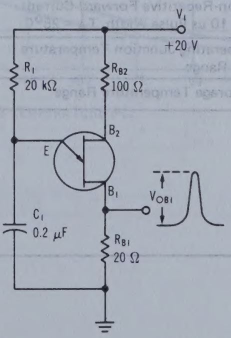
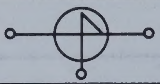


FIGURE 3 — V_{OB1} TEST CIRCUIT

(Typical Relaxation Oscillator)



MUS4987 (SILICON)
MUS4988



SILICON UNIDIRECTIONAL SWITCH

. . . designed for half-wave triggering in SCR phase control circuits, bi-stable memory elements and as voltage level detectors. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

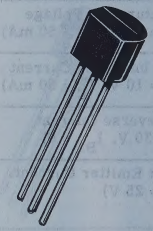
- Low Switching Voltage – 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage – 1.5 Volts Maximum
- Low Off-State Current – 0.1 μA Maximum
- Low Temperature Coefficient – 0.02%/°C Typical

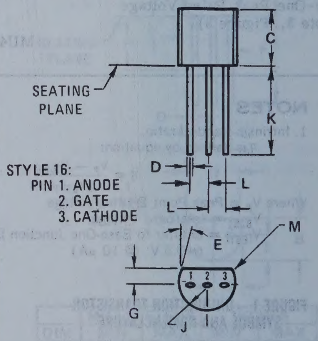
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation Derate above T_A = 25°C	P_D	300 3.0	mW mW/°C
Peak Reverse Voltage	V_R	30	Vdc
DC Forward Anode Current Derate above T_A = 25°C	I_F	200 2.0	mA mA/°C
DC Gate Current (off-state only)	I_G(off)	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, T_A = 100°C)	I_{FM}(rep)	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, T_A = 25°C	I_{FM}(nonrep)	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

SILICON UNIDIRECTIONAL SWITCH (PLASTIC)

6.0-10 VOLTS
300 mW





	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
C	4.450	4.700	0.175	0.185
D	0.407	0.482	0.016	0.019
E	5° NOM		5° NOM	
G	1.150	1.390	0.045	0.055
J	2.160	2.420	0.085	0.095
K	12.700	–	0.500	–
L	1.270 TP		0.050 TP	
M	0.076	0.330	0.003	0.013

CASE 29-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Switching Voltage		V_S				Vdc
	MUS4987		6.0	8.0	10	
	MUS4988		7.5	8.0	9.0	
Switching Current		I_S				μAdc
	MUS4987		–	110	500	
	MUS4988		–	80	150	
Reverse Current		I_R				μAdc
(V_R = 30 V, T_A = 25°C)	MUS4987		–	–	0.1	
(V_R = 30 V, T_A = 85°C)	MUS4987		–	–	1.0	
(V_R = 30 V, T_A = 25°C)	MUS4988		–	–	0.1	
(V_R = 30 V, T_A = 100°C)	MUS4988		–	–	1.0	
Holding Current		I_H				mAdc
	MUS4987		–	0.14	1.5	
	MUS4988		–	0.11	0.5	
Forward Blocking Current		I_B				μAdc
(V_F = 5.0 Vdc, T_A = 25°C)	MUS4987		–	–	0.1	
(V_F = 5.0 Vdc, T_A = 85°C)	MUS4987		–	–	1.0	
(V_F = 5.0 Vdc, T_A = 25°C)	MUS4988		–	–	0.1	
(V_F = 5.0 Vdc, T_A = 100°C)	MUS4988		–	–	1.0	
Forward On-State Voltage (I_F = 150 mAdc)		V_F	–	1.32	1.5	Vdc
Peak Output Voltage (C_c = 0.1 μF, R_L = 20 ohms, Figure 9)		V_o	3.5	4.6	–	Vdc
Turn-On Time (Figure 10)		t_{on}	–	1.0	–	μs
Turn-Off Time (Figure 11)		t_{off}	–	25	–	μs
Temperature Coefficient of Switching Voltage		TC	–	+0.02	–	%/°C

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE

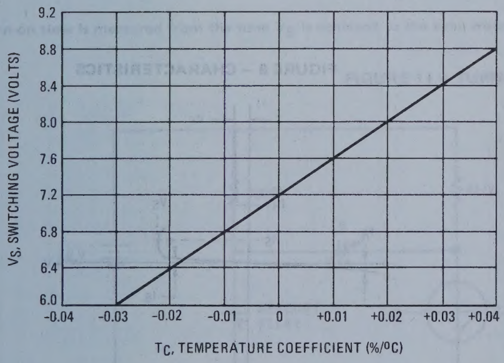


FIGURE 2 – SWITCHING CURRENT

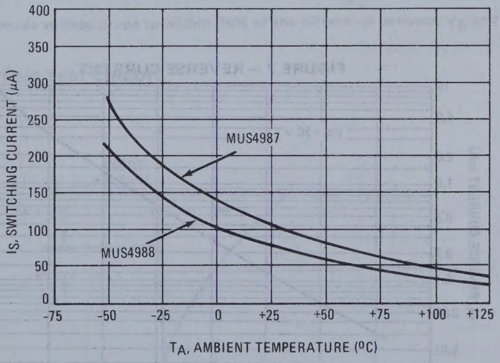


FIGURE 3 – HOLDING CURRENT

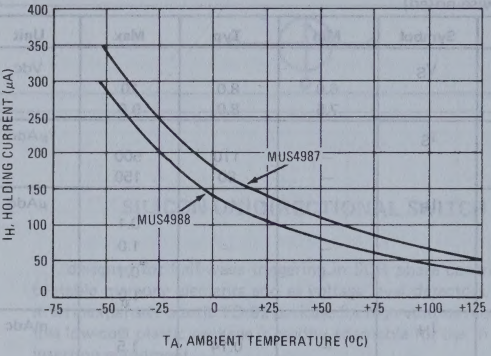


FIGURE 4 – FORWARD BLOCKING CURRENT

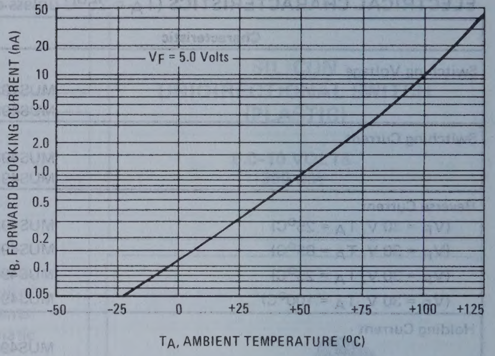


FIGURE 5 – FORWARD ON-STATE VOLTAGE

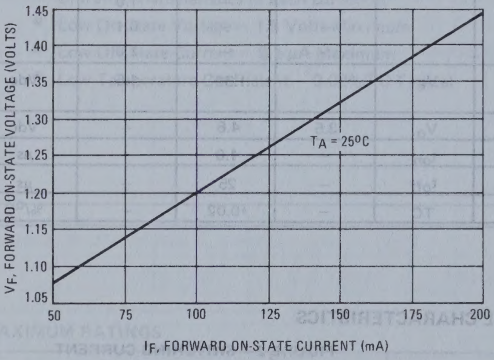


FIGURE 6 – OUTPUT VOLTAGE (FUNCTION OF R_L AND C_c)

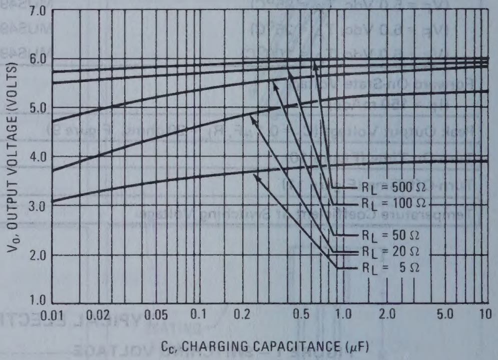


FIGURE 7 – REVERSE CURRENT

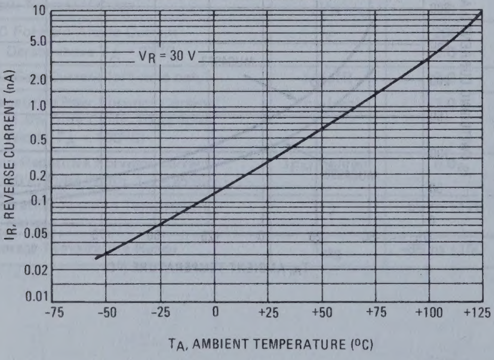


FIGURE 8 – CHARACTERISTICS

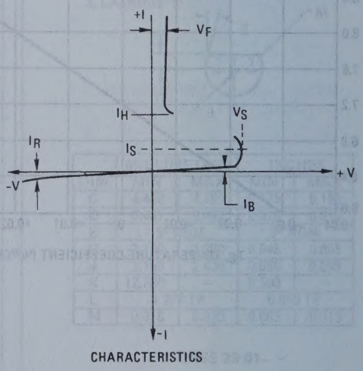

+I
V_F
I_H
V_S
I_R
I_S
-V
+V
I_B
-I
CHARACTERISTICS

FIGURE 9 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

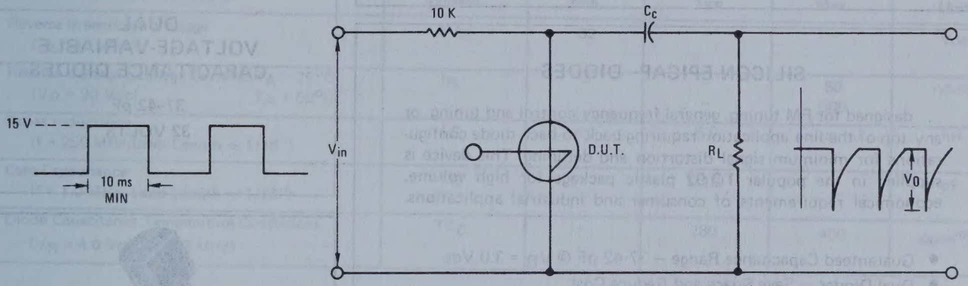
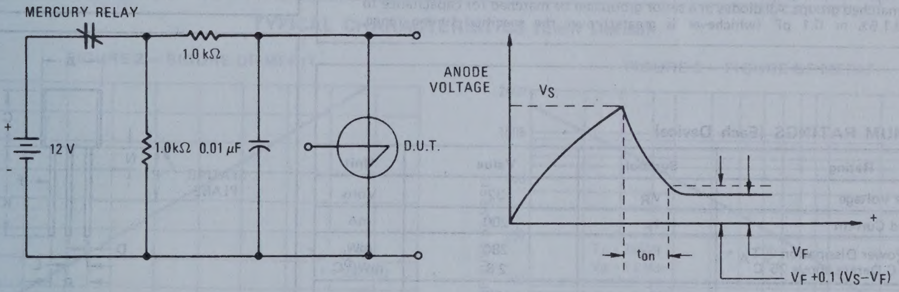
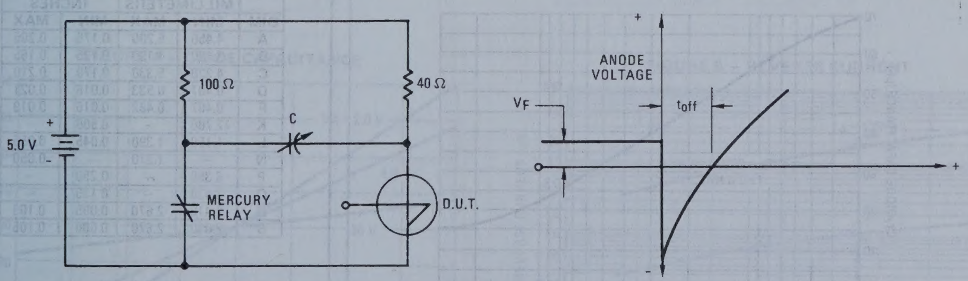

15 V
10 ms MIN
10 K
C_c
V_{in}
D.U.T.
R_L
V_O

FIGURE 10 – TURN-ON TIME TEST CIRCUIT


MERCURY RELAY
1.0 kΩ
12 V
1.0kΩ
0.01 μF
D.U.T.
ANODE VOLTAGE
V_S
t_{on}
V_F
V_F +0.1 (V_S–V_F)

Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F.

FIGURE 11 – TURN-OFF TIME TEST CIRCUIT


100 Ω
40 Ω
5.0 V
C
MERCURY RELAY
D.U.T.
ANODE VOLTAGE
V_F
t_{off}

With the SUS in conduction and the relay contacts open, the contacts are closed and the anode is driven negative. C is decreased, and when the anode voltage becomes positive, the SUS remains off. The turn-off time, t_{off}, is the time between initial contact closure and the point where the anode voltage passes through zero volts.

MV104 (SILICON)

VVC

SILICON EPICAP DIODES

. . . designed for FM tuning, general frequency control and tuning, or any top-of-the-line application requiring back-to-back diode configurations for minimum signal distortion and detuning. This device is supplied in the popular TO-92 plastic package for high volume, economical requirements of consumer and industrial applications.

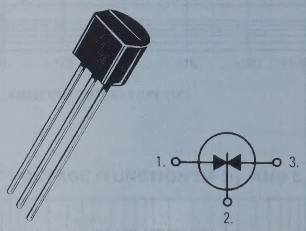
- Guaranteed Capacitance Range – 37-42 pF @ V_R = 3.0 Vdc
- Dual Diodes – Save Space and Reduce Cost
- TO-92 Package for Easy Handling and Mounting
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group
- Monolithic Chip Provides Near Perfect Matching – Guaranteed ± 1% (Max) Over Specified Tuning Range.

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±1.5% or 0.1 pF (whichever is greater) over the specified tuning range.

DUAL VOLTAGE-VARIABLE CAPACITANCE DIODES

37-42 pF

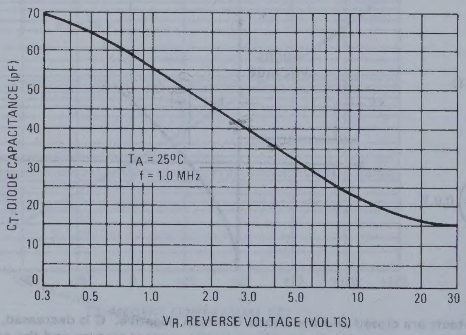
32 VOLTS

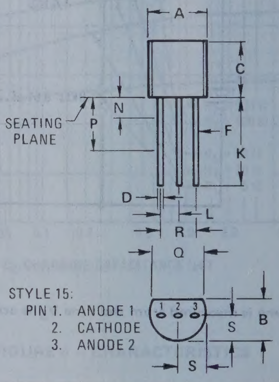


MAXIMUM RATINGS (Each Device)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	32	Volts
Forward Current	I_F	200	mA
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 – DIODE CAPACITANCE (Each Device)





STYLE 15:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, Each Device)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	32	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 30 Vdc) T_A = 25°C T_A = 60°C	I_R	– –	– –	50 500	nAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	–	280	400	ppm/°C

Device	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF		Q, Figure of Merit V_R = 3.0 Vdc f = 100 MHz	C_R, Capacitance Ratio C_3/C_{30} f = 1.0 MHz	
	Min	Max	Min	Min	Max
MV104	37	42	100	2.5	2.8

TYPICAL CHARACTERISTICS (Each Device)

FIGURE 2 – FIGURE OF MERIT

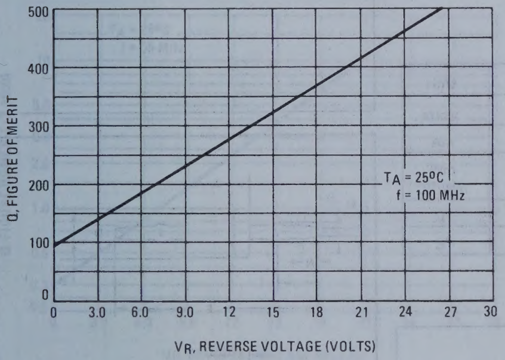


FIGURE 3 – FIGURE OF MERIT

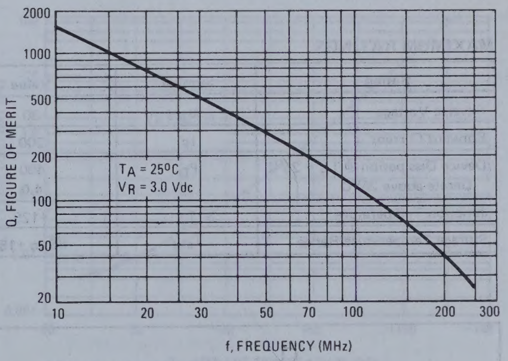


FIGURE 4 – DIODE CAPACITANCE

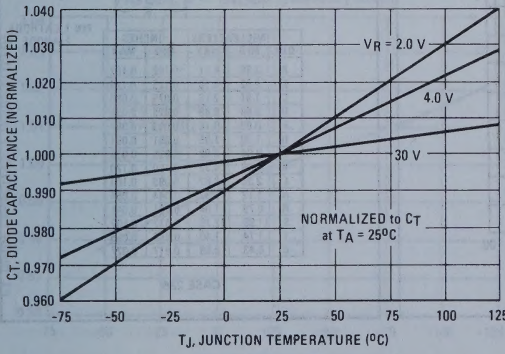
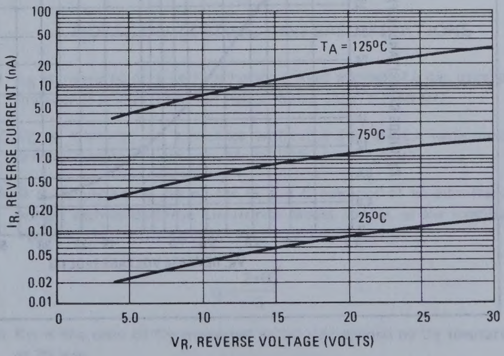


FIGURE 5 – REVERSE CURRENT



MV109 (SILICON)

VOLTAGE VARIABLE CAPACITANCE DIODE

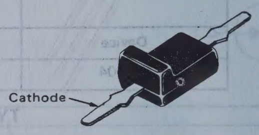
26-32 pF

SILICON EPICAP DIODE

. . . designed in the new low-inductance Mini-L package for high volume requirements in VHF TV tuning, AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

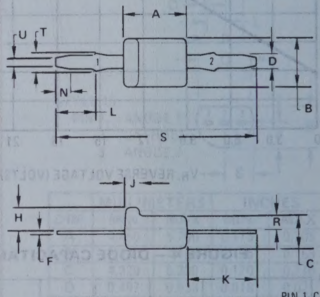
- High Q With Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Low Inductance Mini-L Package
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±3% or 0.1 pF (whichever is greater) along the entire specified tuning range.



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

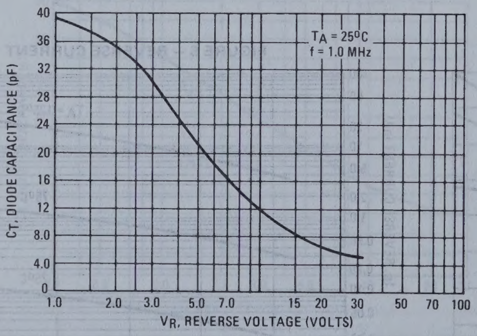


PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

FIGURE 1 – DIODE CAPACITANCE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic–All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 28 Vdc, T_A = 25°C)	I_R	–	–	0.1	μAdc
Series Inductance (f = 250 MHz, Measured at Lead Stop≈1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

Device	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz		Package	
	Min	Nom	Max	Min	Min	Max	Body Stripe Color	Ridge Stripe Color
MV109	26	29	32	280	5.0	6.5	RED	YELLOW

FIGURE 2 – FIGURE OF MERIT

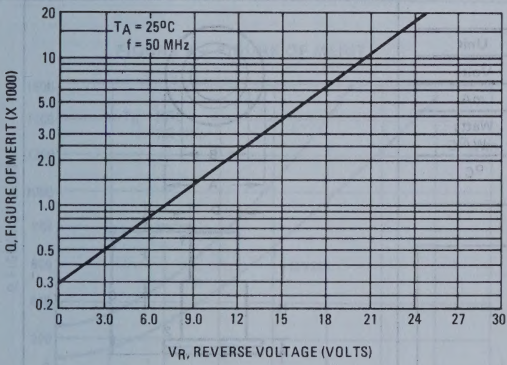


FIGURE 3 – LEAKAGE CURRENT

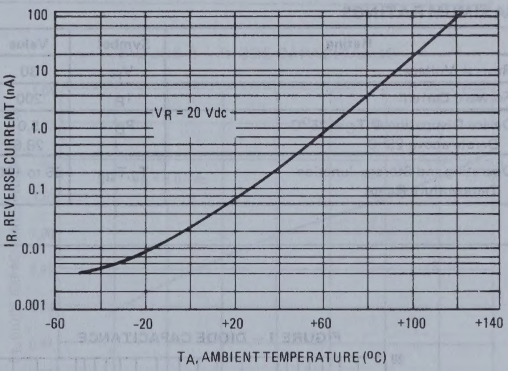
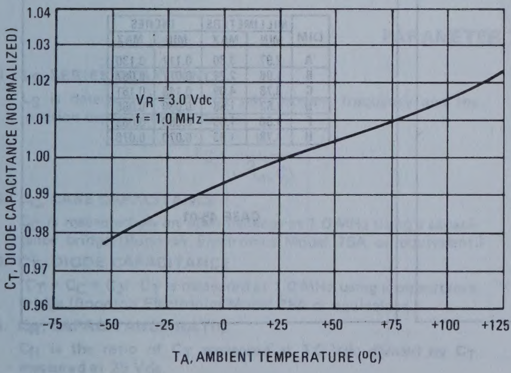


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

MV205 (SILICON)
MV206

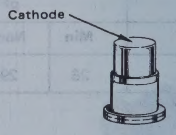
VVC

SILICON HYPER-ABRUPT TUNING DIODES

. . . designed for microwave tuning applications where minimum package parasitics are required.

- High Guaranteed Q @ 100 MHz –
  Q = 225 (Min) – MV205
  = 150 (Min) – MV206
- Guaranteed Tuning Ratio, C3/C25 @ 1.0 MHz –
  C_R = 4.5 (Min) – MV205
  = 4.0 (Min) – MV206
- Supplied in Rugged Hermetic Ceramic Package

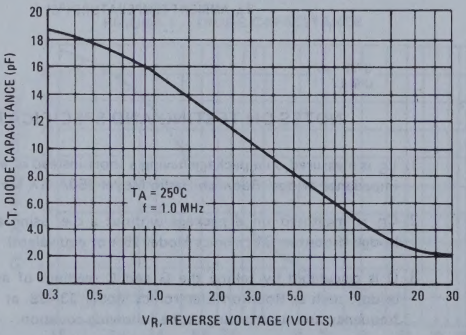
VOLTAGE VARIABLE CAPACITANCE DIODES

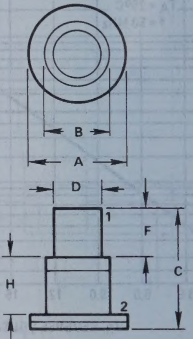


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 – DIODE CAPACITANCE





STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.97	3.30	0.117	0.130
B	1.96	2.21	0.077	0.087
C	3.78	4.09	0.149	0.161
D	1.52	1.68	0.060	0.066
F	1.50	1.65	0.059	0.065
H	1.78	1.93	0.070	0.076

CASE 45-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic — All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 28 V) (V_R = 28, T_A = 60°C)	I_R	— —	— —	50 0.5	nAdc μAdc
Series Inductance (1) (f = self resonant frequency)	L_S	—	0.8	—	nH
Case Capacitance (2) (f = 1.0 MHz)	C_C	—	0.15	—	pF
Diode Capacitance Temperature Coefficient (6) (V_R = 3.0 Vdc, f = 1.0 MHz, -55°C to +125°C)	TC_c	—	—	400	ppm/°C

Device Type	C_T (2),(3) V_R = 25 Vdc pF		Q (5) f = 100 MHz C_T = 9 pF	C_R (4) f = 1.0 MHz C_3/C_{25}	
	Min	Max	Min	Min	Max
MV205	2.0	2.3	225	4.5	6.0
MV206	1.8	2.8	150	4.0	6.0

FIGURE 2 – FIGURE OF MERIT

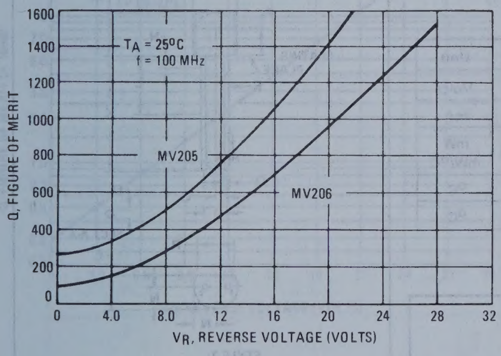
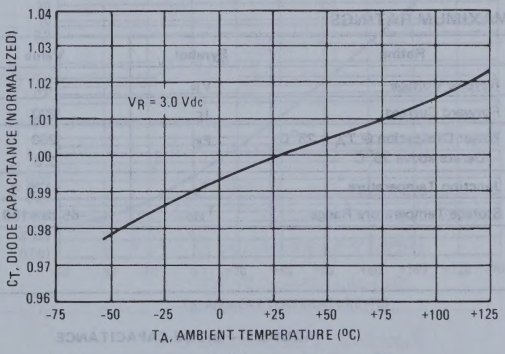


FIGURE 3 – DIODE CAPACITANCE



PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is determined from the self resonant frequency and the junction capacity of the device.

$$L_S = \frac{1}{\omega^2_{res}\, C_J}$$

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent.)

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent.)

4. C_R, CAPACITANCE RATIO

C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

5. Q, FIGURE OF MERIT

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi f C}{G}$$

(Boonton Electronics Model 33AS8 or equivalent).

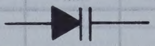
6. TC_c, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_c is guaranteed by comparing C_T at V_R = 3.0 Vdc, f = 1.0 MHz, T_A = -55°C with C_T at V_R = 3.0 Vdc, f = 1.0 MHz, T_A = +125°C in the following equation, which defines TC_c:

$$TC_c = \frac{|C_T(+125^\circ C) - C_T(-55^\circ C)| \times 10^6}{(55 + 125)\ C_T(25^\circ C)}$$

Accuracy limited by C_T measurement, ±0.1 pF.

MV209 (SILICON)

VVC


SILICON EPICAP DIODE

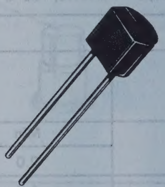
. . . designed for VHF TV tuning, AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q With Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Guaranteed Matching(1) Tolerance From Diode to Diode and Group to Group
- Supplied in One-Piece, Unibloc Package for High Reliability.

(1) Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±3% or 0.1 pF (whichever is greater) along the entire specified tuning range.

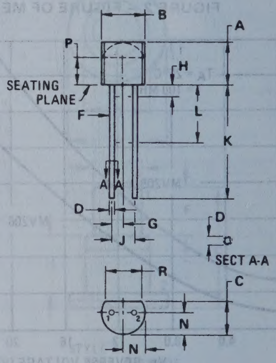
VOLTAGE VARIABLE CAPACITANCE DIODE

26–32 pF



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



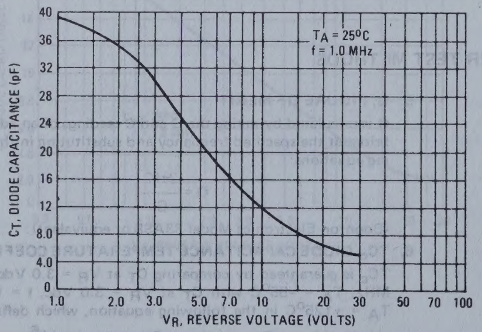
STYLE 2:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

All JEDEC dimensions and notes apply.

CASE 182-02

FIGURE 1 – DIODE CAPACITANCE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	–	–	0.1	μAdc
Series Inductance (Note 1) (f = 250 MHz, Lead Length ≈ 1/8")	L_S	–	6.0	–	nH
Case Capacitance (Note 2) (f = 1.0 MHz)	C_C	–	0.2	–	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

	C_t, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz (Note 3)	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz (Note 4)	
Device	Min	Nom	Max	Min	Min	Max
MV209	26	29	32	200	5.0	6.5

FIGURE 2 – FIGURE OF MERIT

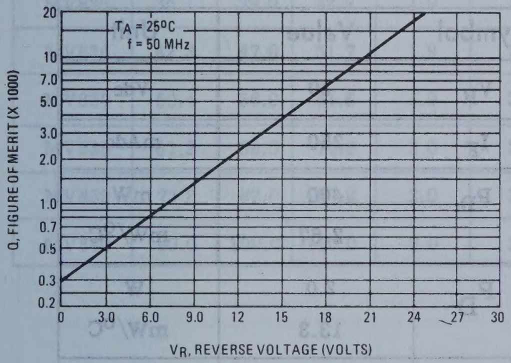


FIGURE 3 – LEAKAGE CURRENT

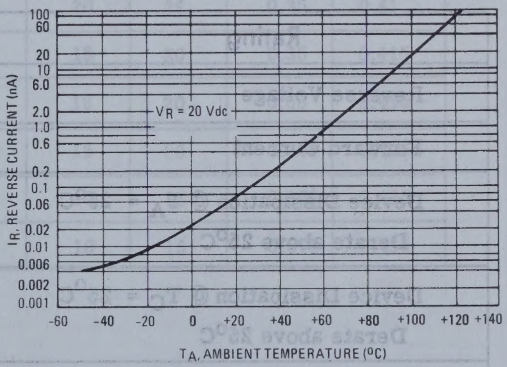
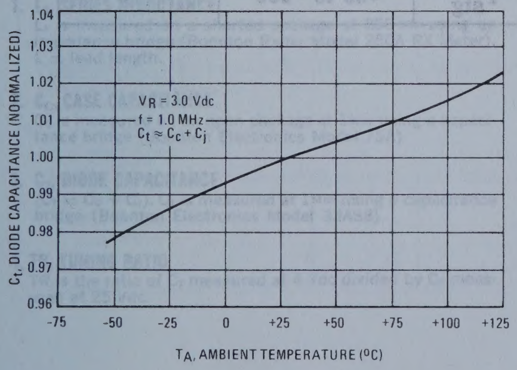


FIGURE 4 – DIODE CAPACITANCE



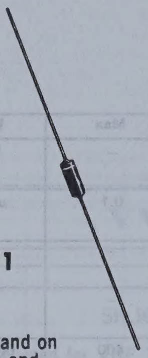
NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi f C}{G}$$

4. C_R is the ratio of C_t measured at 3.0 Vdc divided by C_t measured at 25 Vdc.

MV830 thru **MV840** (SILICON)



CASE 51
(DO-7)

Polarity band on
cathode end

Silicon voltage-variable capacitance diodes, designed for electronic-tuning applications from 15 to 100 pF.

MAXIMUM RATINGS (T$_C$ = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	250	mAdc
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 13.3	W mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted) See Notes

Characteristic — All Types	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	30	—	—	Vdc
Reverse Voltage Leakage Current	I_R	V_R = 25 Vdc	—	—	0.2	μAdc
Series Inductance	L_S	f = 250 MHz, L ≈ 1/16''	—	5	10	nH
Case Capacitance	C_C	f = 1 MHz, L = 0	—	0.25	0.3	pF

	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			TR, Tuning Ratio f = 1 MHz C_4/C_{25}		Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz		α	
Device	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Min**	**Typ**	**Min**	**Typ**
MV830	13.5	15.0	16.5	1.8	2.00	30	35	0.32	0.375
MV831	16.2	18.0	19.8	1.8	2.00	25	30	0.32	0.375
MV832	19.8	22.0	24.2	1.8	2.10	25	30	0.32	0.40
MV833	24.3	27.0	29.7	1.8	2.10	25	30	0.32	0.40
MV834	29.7	33.0	36.3	1.9	2.12	20	25	0.35	0.41
MV835	35.1	39.0	42.9	1.9	2.12	20	25	0.35	0.41
MV836	42.3	47.0	51.7	1.9	2.15	15	20	0.35	0.415
MV837	50.4	56.0	61.6	1.9	2.15	15	20	0.35	0.415
MV838	61.2	68.0	74.8	2.0	2.18	15	20	0.375	0.425
MV839	73.8	82.0	90.2	2.0	2.18	10	15	0.375	0.425
MV840	90.0	100.0	110.0	2.0	2.18	10	15	0.375	0.425

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter). L = lead length.

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1MHz using a capacitance bridge (Boonton Electronics Model 75A).

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1MHz using a capacitance bridge (Boonton Electronics Model 33AS8).

4. TR, TUNING RATIO

TR is the ratio of C_T measured at 4 Vdc divided by C_T measured at 25 Vdc.

5. Q, FIGURE OF MERIT

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8).

6. α, DIODE CAPACITANCE REVERSE VOLTAGE SLOPE

The diode capacitance, C_T (as measured at $V_R = 4$Vdc, f = 1 MHz) is compared to C_T (as measured at $V_R = 30$Vdc, f = 1 MHz) by the following equation which defines α.

$$\alpha = \frac{\log C_T(4) - \log C_T(30)}{\log 30 - \log 4}$$

Note that a C_T versus V_R law is assumed as shown in the following equation where C_C is included.

$$C_T = \frac{K}{V^{\alpha}}$$

MV1401, MV1403 (SILICON)
MV1404, MV1405

VVC

SILICON HYPER-ABRUPT JUNCTION TUNING DIODES

. . . designed with a capacitance change of greater than TEN TIMES for a bias change ranging from 2 to 10 volts. Provides tuning over broad frequency ranges, tuning AM radio broadcast band, general AFC and tuning applications in lower RF frequencies.

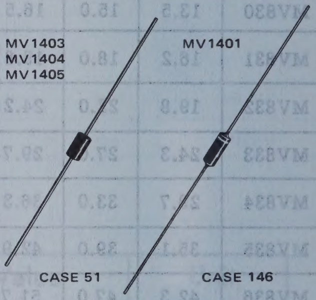
- High Q with Guaranteed Minimum Values
- Broad Capacitance Selection from 120–550 pF (Nominal Values)
- Available in Two Standard Glass Packages

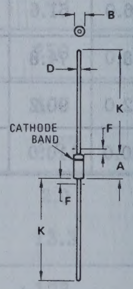
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HIGH TUNING RATIO VOLTAGE – VARIABLE CAPACITANCE DIODES

120-550 pF
12 VOLTS

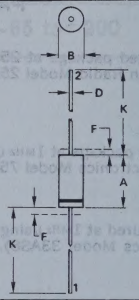




DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.74	3.56	0.108	0.140
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply.

STYLE 1:
PIN 1. CATHODE
2. ANODE

CASE 146
DO-204AB

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	12	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, T_A = 25°C)	I_R	—	—	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16″)	L_S	—	5.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	—	0.25	—	pF

	C_T, Diode Capacitance						Q, Figure of Merit	TR, Tuning Ratio	
	V_R = 1.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz	C_1/C_{10} f = 1.0 MHz	C_2/C_{10} f = 1.0 MHz
Device	Min	Nom	Max	Min	Nom	Max	Min	Min	Min
MV1401	468	550	633	—	—	—	200	14	—
MV1403	—	—	—	140	175	210	200	—	10
MV1404	—	—	—	96	120	144	200	—	10
MV1405	—	—	—	200	250	300	200	—	10

PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE**

   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. **C_C, CASE CAPACITANCE**

   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. **C_T, DIODE CAPACITANCE**

   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. **TR, TUNING RATIO**

   TR is the ratio of C_T measured at 2.0 Vdc (1.0 Vdc for MV1401) divided by C_T measured at 10 Vdc.

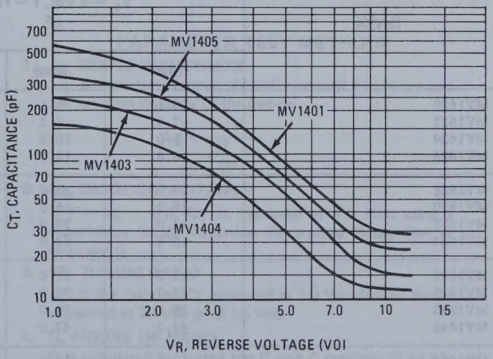
5. **Q, FIGURE OF MERIT**

   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equation:

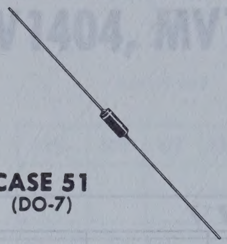
$$Q = \frac{2\pi f C}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16″.

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE



MV1620 thru MV1650 (SILICON)



CASE 51
(DO-7)

Silicon Epicap diodes, epitaxial passivated tuning diodes designed for AFC applications in radio, TV, and general electronic-tuning.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	250	mAdc
Device Dissipation @ T_A = 25°C	P_D	400	mW
Derate above 25°C		2.67	mW/°C
Device Dissipation @ T_C = 25°C	P_D	2	Watts
Derate above 25°C		13.3	mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

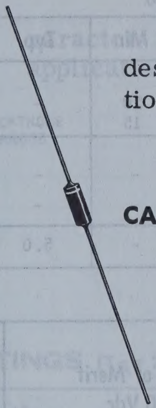
Characteristic – All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	20	–	–	Vdc
Reverse Voltage Leakage Current	V_R = 15 Vdc	I_R	–	–	0.1	μAdc
Series Inductance	f = 250 MHz, lead length ≈ 1/16"	L_S	–	5.0	10	nH
Case Capacitance	f = 1 MHz, lead length ≈ 1/16"	C_C	–	0.25	0.3	pF

Device	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz	TR, Tuning Ratio * C_2/C_{20} f = 1 MHz	
	Min	Nom	Max	Min	Min	Max
MV1620	6.1	6.8	7.5	300	2.0	3.2
MV1622	7.4	8.2	9.0	300	2.0	3.2
MV1624	9.0	10.0	11.0	300	2.0	3.2
MV1626	10.8	12.0	13.2	300	2.0	3.2
MV1628	13.5	15.0	16.5	250	2.0	3.2
MV1630	16.2	18.0	19.8	250	2.0	3.2
MV1632	18.0	20.0	22.0	250	2.0	3.2
MV1634	19.8	22.0	24.2	250	2.0	3.2
MV1636	24.3	27.0	29.7	200	2.0	3.2
MV1638	29.7	33.0	36.3	200	2.0	3.2
MV1640	35.1	39.0	42.9	200	2.0	3.2
MV1642	42.3	47.0	51.7	200	2.0	3.2
MV1644	50.4	56.0	61.6	150	2.0	3.2
MV1646	61.2	68.0	74.8	150	2.0	3.2
MV1648	73.8	82.0	90.2	150	2.0	3.2
MV1650	90.0	100.0	110.0	150	2.0	3.2

* TR, Tuning Ratio, is the ratio of C_T measured at 2 Vdc divided by C_T measured at 20 Vdc.

MV1652 (SILICON)
MV1654
MV1656
MV1658
MV1660
MV1662
MV1664
MV1666

Silicon epicap epitaxial passivated tuning diodes designed for general tuning, trimming and AFC applications at low radio frequencies.

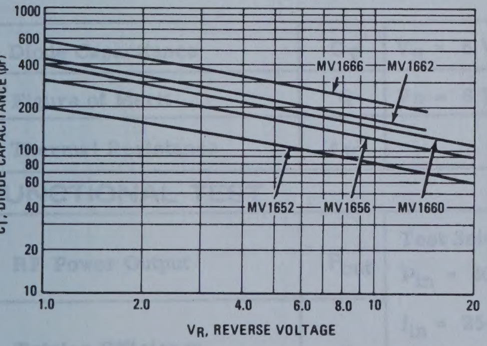


CASE 146

MAXIMUM RATINGS

Rating	Symbol	MV1652 MV1654 MV1656 MV1658 MV1660	MV1662 MV1664 MV1666	Unit
Reverse Voltage	V_R	20	15	Vdc
Forward Current	I_F	400		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67		mW mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

FIGURE 1 - DIODE CAPACITANCE versus REVERSE VOLTAGE



PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE**
   L_S, is determined from the self resonant frequency and the junction capacity of the device.

$$L_S = \frac{1}{\omega_{res}^2 C_J}$$

2. **C_T, DIODE CAPACITANCE**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. **TR, TUNING RATIO**
   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 20 Vdc or at 15 Vdc.
4. **Q, FIGURE OF MERIT**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS9 with range extender or equivalent).

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

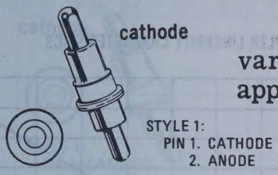
Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	MV1652 thru MV1660	BV_R	20	-	-	Vdc
	MV1662 thru MV1666		15	-	-	
Reverse Current (V_R = 15 Vdc)	MV1652 thru MV1660	I_R	-	-	0.1	μAdc
(V_R = 10 Vdc)	MV1662 thru MV1666		-	-	0.1	
Series Inductance	MV1652 thru MV1666	L_S	-	5.0	-	nH

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz (pF)			Q, Figure of Merit V_R = 4.0 Vdc, f = 20 MHz	Capacitance Ratio C_2/C_{20}
	Min	Nom	Max		Typical
MV1652	108	120	135	250	2.6
MV1654	132	150	165	250	2.6
MV1656	162	180	198	200	2.6
MV1658	180	200	220	200	2.6
MV1660	198	220	242	150	2.6
					C_2/C_{15}
MV1662	225	250	275	150	2.3
MV1664	243	270	300	100	2.3
MV1666	297	330	363	100	2.3

MV1803 (SILICON)

For Specifications, See 2N3137 Data, Volume I.

MV1805C (SILICON)



CASE 47

High-frequency step-recovery silicon power varactor for 100 MHz to 2.0 GHz harmonic-generation applications with output power up to 35 watts at 1.0 GHz.

MAXIMUM RATINGS ($T_A = 25^oC$ unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	80	Volts
Forward Current	I_F	5.0	Amps
RF Power Input	P_{in}	50	Watts
Total Device Dissipation @ $T_A = 75^oC$	P_D	18	Watts
Derate above 75^oC		0.14	W/^oC
Junction Temperature	T_J	+200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	$I_R = 10\ \mu Adc$	80	95	—	Vdc
Reverse Current	I_R	$V_R = 70$ Vdc $V_R = 70$ Vdc, $T_A = 150^oC$	— —	— —	2 100	μAdc
Diode Capacitance	C_T	$V_R = 6$ Vdc, f = 1.0 MHz	20	25	30	pF
Figure of Merit	Q	$V_R = 6$ Vdc, f = 50 MHz	—	500	—	—
Thermal Resistance	θ_{JC}		—	—	7	$^oC/W$

FUNCTIONAL TEST

RF Power Output	P_{out}	Test Setup Figure 4 $P_{in} = 40$ Watts	26	—	—	Watts
Tripler Efficiency	η	$f_{in} = 250$ MHz $f_{out} = 750$ MHz	65	—	—	%

POWER OUTPUT versus OUTPUT FREQUENCY

FIGURE 1A — DOUBLING (X2)

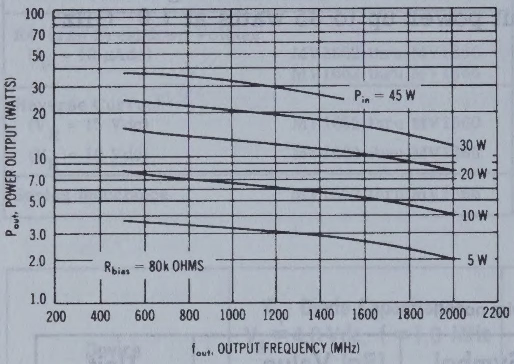


FIGURE 1B — TRIPLING (X3)

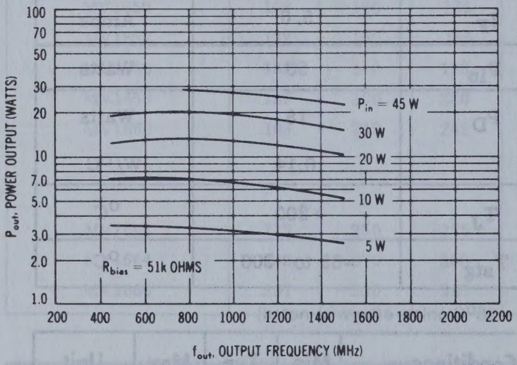


TABLE 1 — TYPICAL QUADRUPLING (X4)

f_{in} = 275 MHz, f_{out} = 1100 MHz, R_{bias} = 100k OHMS

INPUT POWER Watts	OUTPUT POWER Watts	EFFICIENCY %
5	2.6	52
10	5.4	54
20	10.6	53
30	14.4	48
40	19.0	47.5
45	20.6	45.8

TABLE 2 — TYPICAL ONE-STEP (X9)

f_{in} = 50 MHz, f_{out} = 450 MHz, R_{bias} = 5k OHMS

INPUT POWER Watts	OUTPUT POWER Watts	EFFICIENCY %
5	1.4	28
10	2.7	27

FIGURE 2 — TRIPLER LINEARITY CHARACTERISTICS

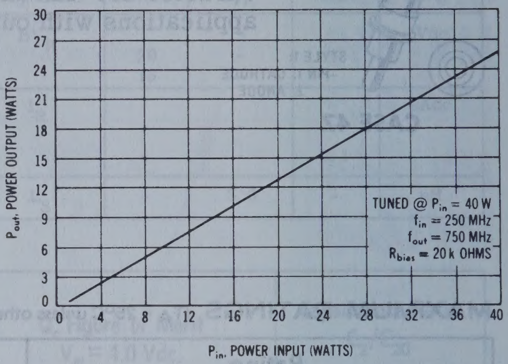


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE

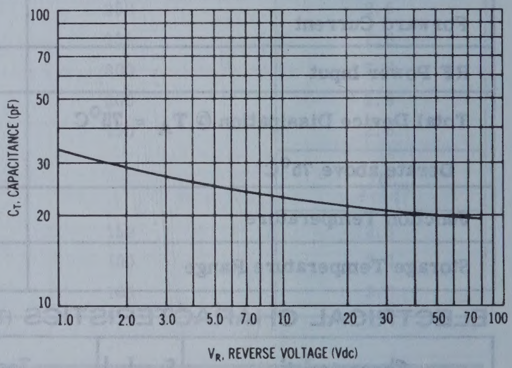
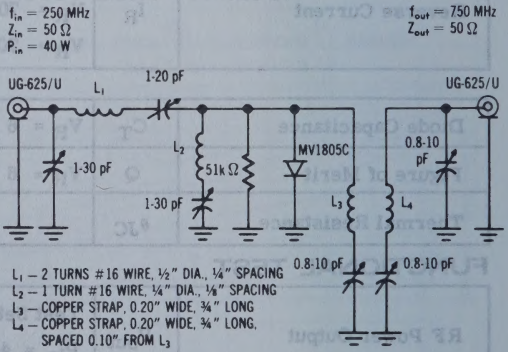
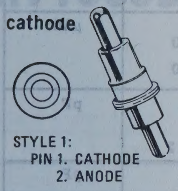


FIGURE 4 — HARMONIC TRIPLER — 250 MHz to 750 MHz


f_{in} = 250 MHz
Z_{in} = 50 Ω
P_{in} = 40 W
f_{out} = 750 MHz
Z_{out} = 50 Ω
UG-625/U
L_1
1-20 pF
UG-625/U
1-30 pF
L_2
51k Ω
MV1805C
0.8-10 pF
1-30 pF
L_3
L_4
0.8-10 pF
0.8-10 pF

L_1 — 2 TURNS #16 WIRE, ½" DIA., ¼" SPACING
L_2 — 1 TURN #16 WIRE, ¼" DIA., ⅛" SPACING
L_3 — COPPER STRAP, 0.20" WIDE, ¾" LONG
L_4 — COPPER STRAP, 0.20" WIDE, ¾" LONG, SPACED 0.10" FROM L_3

MV1809C1 (SILICON)


cathode
STYLE 1:
PIN 1. CATHODE
2. ANODE

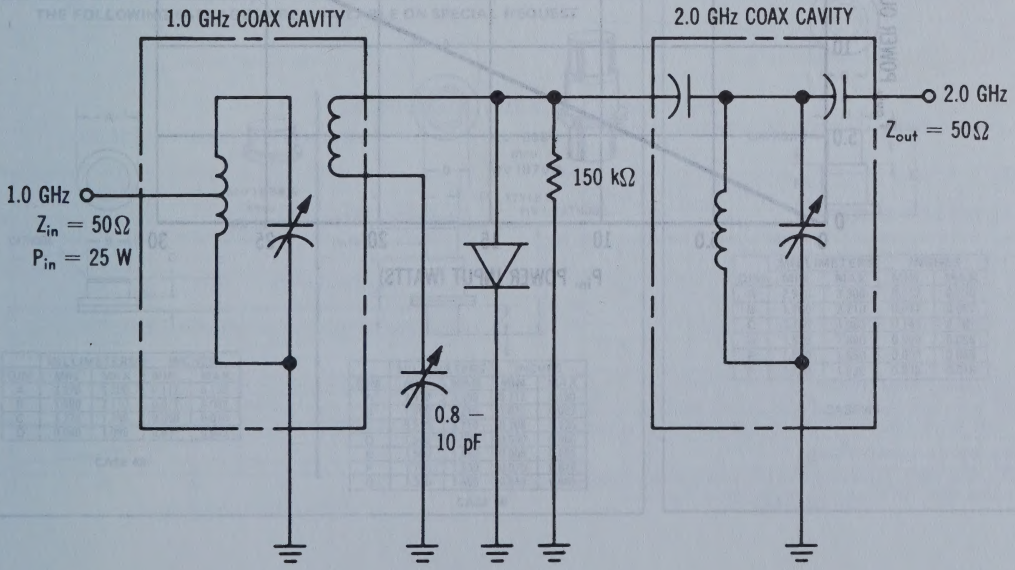
CASE 47

Silicon high-frequency step-recovery power varactors for 300 MHz to 3.0 GHz harmonic-generation applications with output power to 17 watts at 2.0 GHz.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	75	Vdc
Forward Current	I_F	5.0	Adc
RF Power Input	P_{in}	30	Watts
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	14 0.11	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT


1.0 GHz COAX CAVITY
2.0 GHz COAX CAVITY
1.0 GHz
Z_{in} = 50Ω
P_{in} = 25 W
150 kΩ
0.8 —
10 pF
2.0 GHz
Z_{out} = 50Ω

MV1809C1 (continued)

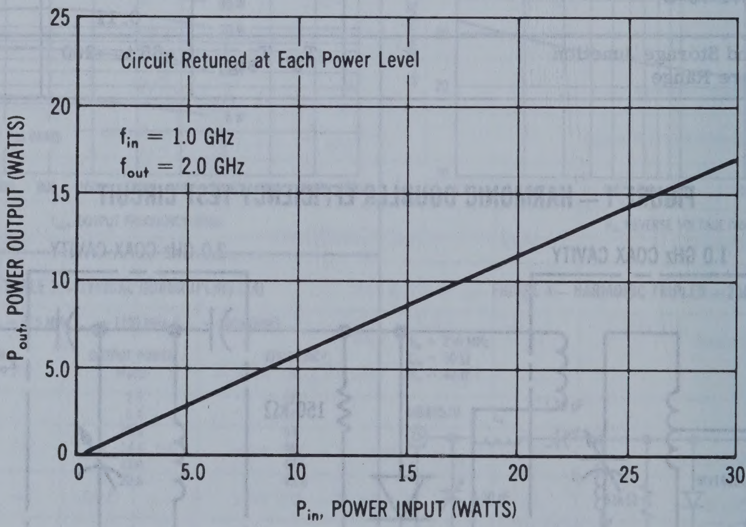
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	75	-	-	Vdc
Reverse Current (V_R = 70 Vdc) (V_R = 70 Vdc, T_A = 150°C)	I_R	- -	- -	2.0 100	μAdc
Diode Capacitance ($C_J + C_C$) (V_R = 6.0 Vdc, f = 1.0 MHz)	C_T	10.8	-	13.2	pF
Case Capacitance	C_C	-	0.47	-	pF
Series Inductance	L_S	-	2.2	-	nH
Series Resistance (V_R = 6.0 Vdc)	R_S	-	0.35	0.5	Ohm
Thermal Resistance	θ_{JC}	-	-	9.0	°C/W

FUNCTIONAL TESTS

MV1809C1						
Power Output	Doubler Test Circuit (Figure 1) P_{in} = 25 W, f_{in} = 1.0 GHz, f_{out} = 2.0 GHz	P_{out}	14.5	-	-	Watt
Efficiency		η	58	-	-	%

FIGURE 2 — POWER OUTPUT versus POWER INPUT



MV1858D, MV1860D, MV1862D, (SILICON) MV1863D, MV1864D, MV1865D, MV1866D, MV1868D, MV1870D

VVC ─▶|├

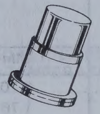
SILICON EPICAP DIODES

. . . designed for electronic tuning and control applications in the UHF and lower microwave frequency ranges, where extremely high Q and broad tuning ratio are required.

- Excellent Q Factor @ f = 100 MHz
- Low Capacitance Values – as low as 1.0 pF
- Wide Tuning Range – to 60 Volts
- Complete Typical Design Curves
- Microwave Ceramic Package

VOLTAGE-VARIABLE CAPACITANCE DIODES

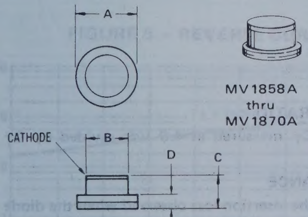
1 to 15 pF
60 VOLTS



MAXIMUM RATINGS

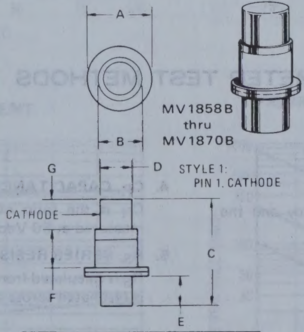
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Volts
Forward Current	I_F	250	mA
Total Device Dissipation @ $T_C = 25^\circ C$ Derate above $25^\circ C$	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THE FOLLOWING PACKAGES ARE AVAILABLE ON SPECIAL REQUEST



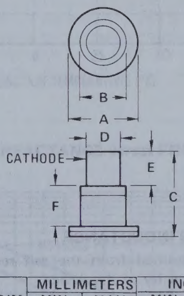
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	2.970	3.300	0.117	0.130
B	1.960	2.110	0.077	0.083
C	1.270	1.780	0.050	0.070
D	0.940	1.090	0.037	0.043

CASE 48



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	2.970	3.300	0.117	0.130
B	1.950	2.210	0.077	0.087
C	5.210	5.710	0.205	0.225
D	1.520	1.670	0.060	0.066
E	1.500	1.650	0.059	0.065
F	1.780	1.930	0.070	0.076
G	1.500	1.650	0.059	0.065

CASE 46



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	2.970	3.300	0.117	0.130
B	1.960	2.210	0.077	0.087
C	3.780	4.090	0.149	0.161
D	1.520	1.680	0.060	0.066
E	1.500	1.650	0.059	0.065
F	1.780	1.930	0.070	0.076

CASE 45

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 µAdc)	B_{VR}	60	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 55 Vdc) (V_R = 55 Vdc, T_A = 150°C)	I_R	– –	– –	0.02 20	µAdc
Series Inductance (f = self-resonant frequency)	L_S	–	0.8	–	nH
Case Capacitance (1) (f = 1.0 MHz)	C_C	–	0.15	–	pF

Device	C_T, Diode Capacitance (2) V_R = 4 Vdc, f = 1.0 MHz pF			C_R, Capacitance Ratio C_4/C_{60} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 100 MHz
	Min	Nom	Max	Min	Max	Min
MV1858D	0.70	1.0	1.30	2.1	2.7	350
MV1860D	1.76	2.2	2.64	2.5	3.1	350
MV1862D	2.97	3.3	3.63	2.6	3.3	300
MV1863D	4.23	4.7	5.17	2.6	3.3	300
MV1864D	6.10	6.8	7.50	2.7	3.4	300
MV1865D	7.38	8.2	9.02	2.7	3.4	300
MV1866D	9.00	10.0	11.00	2.8	3.5	250
MV1868D	10.80	12.0	13.20	2.8	3.5	200
MV1870D	13.50	15.0	16.50	2.8	3.5	200

(1) Case Capacitance = 0.25 pF typical for types MV1858A thru MV1870A (case 48).
(2) All C_T values 0.11 pF higher for types MV1858A thru MV1870A (case 48). C_R is reduced proportionately.

PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE**

L_S is determined from the self resonant frequency and the junction capacity of the device.

$$L_S = \frac{1}{\omega^2{}_{res}\, C_J}$$

2. **C_C, CASE CAPACITANCE**

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent.)

3. **C_T, DIODE CAPACITANCE**

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent.)

4. **C_R, CAPACITANCE RATIO**

C_R is the ratio of C_T measured at 4.0 Vdc divided by C_T measured at 60 Vdc.

5. **R_S, SERIES RESISTANCE**

R_S is calculated from the insertion loss observed when the diode is resonated across a 50-ohm transmission line.

$$R_S = \frac{25}{\log_{10}^{-1}\left(\frac{\text{Insertion Loss}}{20}\right) - 1}$$

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE

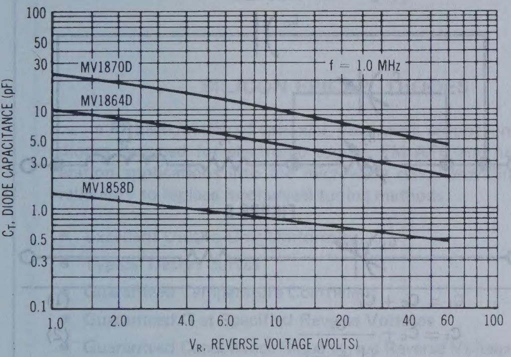


FIGURE 2 – NORMALIZED SERIES RESISTANCE versus REVERSE VOLTAGE

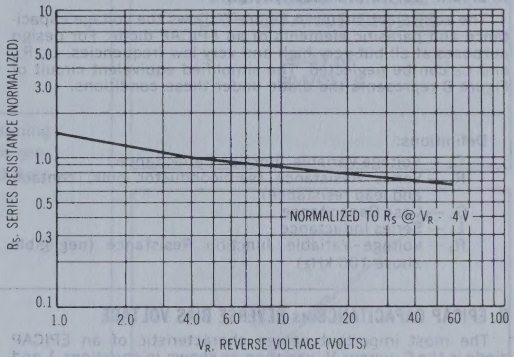


FIGURE 3 – CAPACITANCE VARIATION versus TEMPERATURE

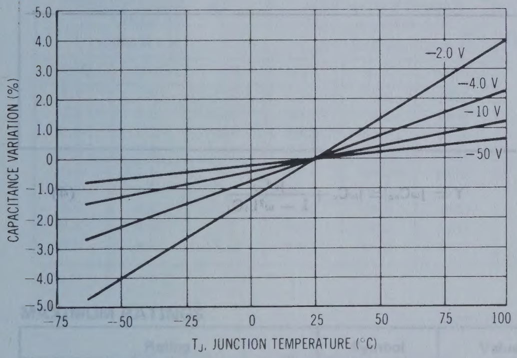


FIGURE 4 – NORMALIZED SERIES RESISTANCE versus TEMPERATURE

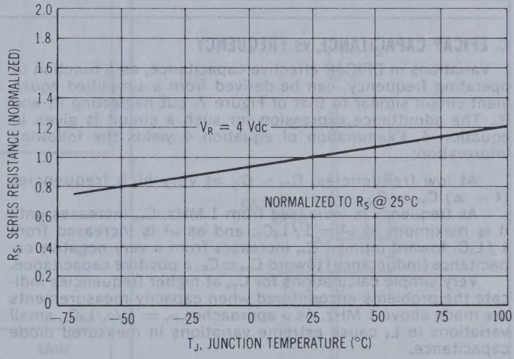


FIGURE 5 – REVERSE CURRENT

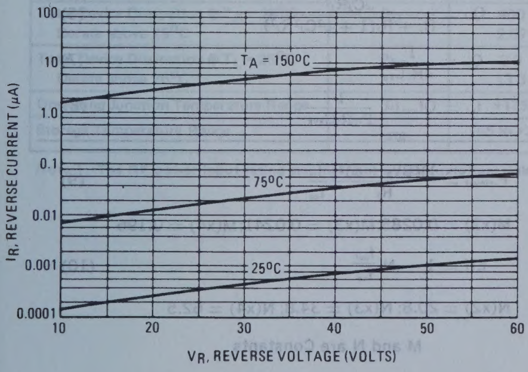
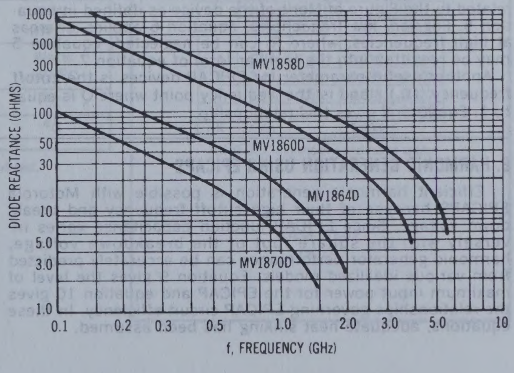


FIGURE 6 – DIODE REACTANCE versus FREQUENCY

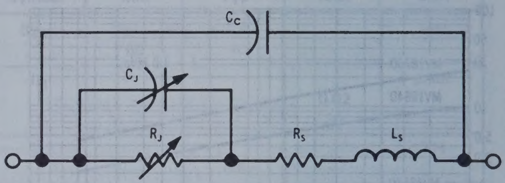


EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. EPICAP NETWORK PRESENTATION

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

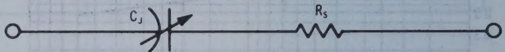
FIGURE 7



Definitions:

C_J — Voltage-Variable Junction Capacitance
R_S — Series Resistance (semiconductor bulk, contact, and lead resistance)
C_C — Case Capacitance
L_S — Series Inductance
R_J — Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 8



B. EPICAP CAPACITANCE vs REVERSE BIAS VOLTAGE

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Since the designer is primarily interested in the slope of C_T versus V_R, the C_C, C_O, ϕ, and γ characteristics have been encompassed by the simplified equation 3. Min/max limits on α can be guaranteed over a specified V_R range.

$$C_T = C_C + C_J \qquad (1)$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \qquad (2)$$

$C_o = C_J$ at $V_R = 0$ $\qquad V_R =$ Reverse Bias
$\phi =$ Contact Potential, $\phi \approx 0.6$ Volt $\qquad \gamma = C_J$ slope, $\gamma \approx 0.5$

$$C_T = \frac{K}{V_R{}^{\alpha}} \qquad (3)$$

C. EPICAP CAPACITANCE vs FREQUENCY

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 4. Examination of equation 4 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies $(f \approx \infty)$ $C_{eq} \approx C_c$.

As frequency is increased from 1 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_c + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \qquad (4)$$

D. EPICAP FIGURE OF MERIT (Q) AND CUTOFF FREQUENCY (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 5. For very low frequencies, equation 6 applies whereas at high frequencies, where R_J can be neglected, equation 5 may be rewritten into the familiar form of equation 7.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 8 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \qquad (5)$$

$$Q_{LF} = \frac{\omega C_J R_J{}^2}{R_J + R_S(1 + \omega^2 C_J{}^2 R_J{}^2)} \qquad (6)$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \qquad (7)$$

$$f_{co} = Q f_{max} \approx \frac{1}{2\pi R_S C_{BVR}} \qquad (8)$$

E. HARMONIC GENERATION USING EPICAPS

Efficient harmonic generation is possible with Motorola EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 9 gives the level of maximum input power for the EPICAP and equation 10 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \qquad (9)$$

$M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196$

$$\text{Eff} = 1 - N \frac{f_{out}}{f_{co}} \qquad (10)$$

$N(x2) = 20.8; N(x3) = 34.8; N(x4) = 62.5$

M and N are Constants

MV1866, MV1868, MV1870, (SILICON)
MV1871, MV1872, MV1874,
MV1876, MV1877, MV1878

VVC

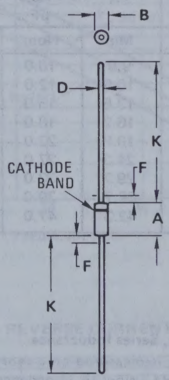
SILICON EPICAP DIODES

. . . a PREMIUM line of epitaxial, passivated, abrupt-junction tuning diodes designed for electronic tuning, FM AFC and harmonic generation applications into the microwave range providing solid-state reliability to replace mechanical tuning methods.

- Excellent Unit-to-Unit Uniformity
- Typical Design Curves
- Guaranteed Temperature Coefficient
- Guaranteed Q at Specified Reverse Voltages
- Guaranteed Capacitance Slope versus Reverse Voltage
- Guaranteed Min/Max Slope of Capacitance versus Reverse Voltage Curve (α)
- Complete Design Curves

VOLTAGE-VARIABLE CAPACITANCE DIODES

10–47 pF
60 VOLTS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

CASE 51-02
DO-7

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Vdc
Forward Current	I_F	250	mAdc
RF Power Input (Note 1)	P_{in}	5.0	Watts
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.67	mW mW/^oC
Total Device Dissipation @ $T_L = 25^oC$ Derate above 25^oC	P_L	2.0 13.3	Watts mW/^oC
Operating Junction Temperature Range	T_J	+175	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

Note 1. The RF power input rating assumes that an adequate heat sink is provided.

MV1866, MV1868, MV1870, MV1871, MV1872, MV1874, MV1876, MV1877, MV1878 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ C$ unless otherwise noted)

Characteristic — All Types	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_R = 10\ \mu Adc$)	BV_R	60	75	–	Vdc
Reverse Current ($V_R = 55$ Vdc) ($V_R = 55$ Vdc, $T_A = 150^\circ C$)	I_R	– –	– –	0.02 2.0	μAdc
Series Inductance (f = 250 MHz, Measured at Lead Stop ≈ 1/16″)	L_S	–	5.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16″)	C_C	–	0.17	–	pF
Diode Capacitance Temperature Coefficient ($V_R = 4.0$ Vdc, f = 1.0 MHz)	TC_C	–	200	300	ppm/°C
Cutoff Frequency ($V_R = 60$ Vdc, f = 50 MHz)	f_{CO}	–	45	–	GHz

Device	C_T, Diode Capacitance $V_R = 4.0$ Vdc, f = 1.0 MHz pF			Q, Figure of Merit f = 50 MHz		α, Diode Capacitance Reverse Voltage Slope $V_R = 4.0$ Vdc to $V_R = 60$ Vdc See B on Back Page			C_R, Capacitance Ratio C4.0/C60 f = 1.0 MHz		
				$V_R = 4.0$ Vdc	$V_R = 60$ Vdc						
	Min	Nom	Max	Min	Min	Min	Typ	Max	Min	Typ	Max
MV1866	9.0	10.0	11.0	500	700	0.42	0.44	0.48	3.0	3.1	3.5
MV1868	10.8	12.0	13.2	500	700	0.42	0.44	0.48	3.0	3.1	3.5
MV1870	13.5	15.0	16.5	400	700	0.42	0.45	0.48	3.0	3.2	3.5
MV1871	16.2	18.0	19.8	400	700	0.42	0.45	0.48	3.0	3.2	3.5
MV1872	19.8	22.0	24.2	400	700	0.45	0.46	0.48	3.2	3.3	3.5
MV1874	24.3	27.0	29.7	300	700	0.45	0.46	0.48	3.2	3.3	3.5
MV1876	29.7	33.0	36.3	300	700	0.45	0.47	0.48	3.2	3.4	3.6
MV1877	36.7	39.0	42.9	300	700	0.45	0.47	0.48	3.2	3.4	3.6
MV1878	42.3	47.0	51.7	300	700	0.45	0.47	0.48	3.2	3.4	3.6

PARAMETER TEST METHODS

1. **L_S, Series Inductance**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).
2. **C_C, Case Capacitance**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. **C_T, Diode Capacitance**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
4. **C_R, Capacitance Ratio**
   C_R is the ratio of C_T measured at 4.0 Vdc divided by C_T measured at 60 Vdc.
5. **Q, Figure of Merit**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

   $$Q = \frac{2\pi f C}{G}$$

   (Boonton Electronics Model 33AS8 or equivalent).
6. **TC_c, Diode Capacitance Temperature Coefficient**
   TC_c is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, $T_A = -65^\circ C$ with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, $T_A = +85^\circ C$ in the following equation, which defines TC_c:

   $$TC_c = \left| \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \right| \frac{10^6}{C_T(25^\circ C)}$$

   Accuracy limited by C_T measurement to ±0.1 pF.

MV1866, MV1868, MV1870, MV1871, MV1872, MV1874, MV1876, MV1877, MV1878 (continued)

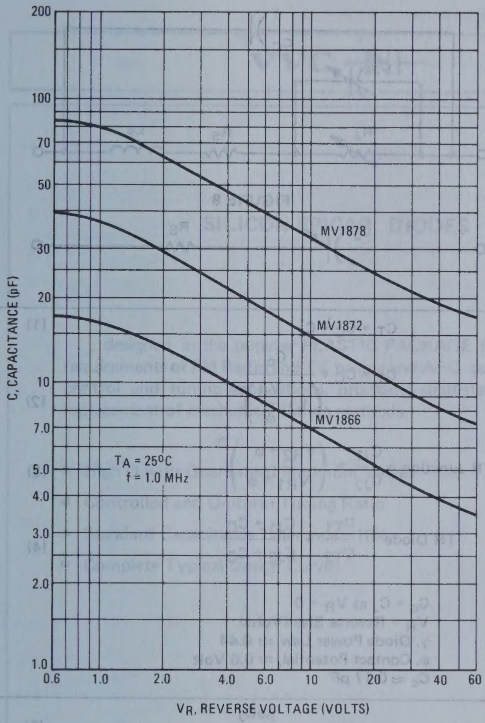


FIGURE 1 – DIODE CAPACITANCE

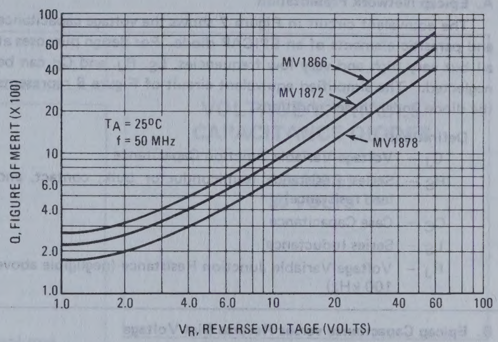


FIGURE 2 – FIGURE OF MERIT

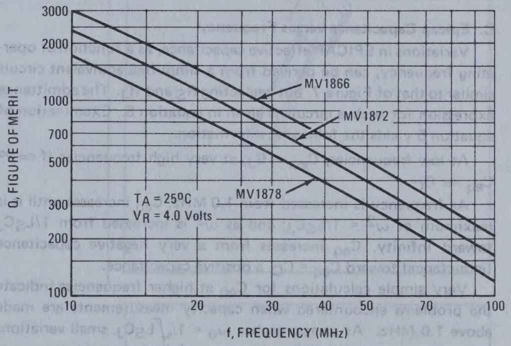


FIGURE 3 – FIGURE OF MERIT

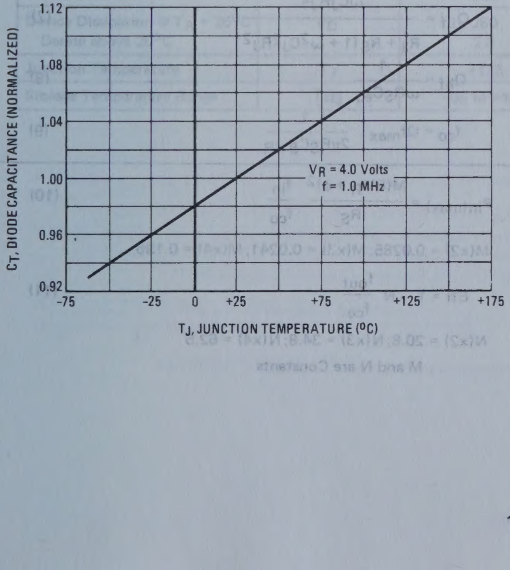


FIGURE 4 – DIODE CAPACITANCE

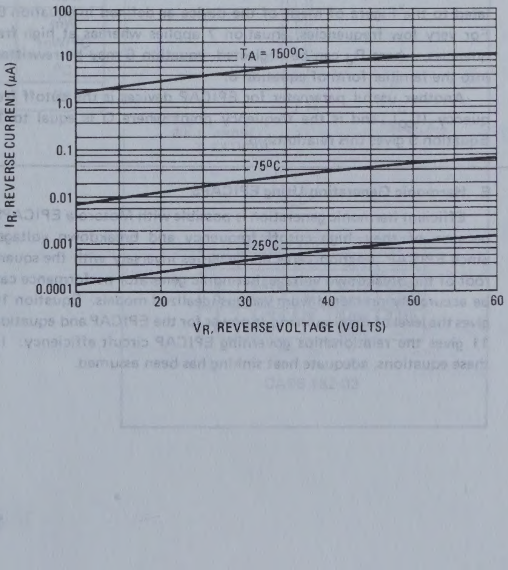


FIGURE 5 – REVERSE CURRENT

EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

Definitions:

C_J – Voltage-Variable Junction Capacitance

R_S – Series Resistance (semiconductor bulk, contact, and lead resistance)

C_C – Case Capacitance

L_S – Series Inductance

R_J – Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 7

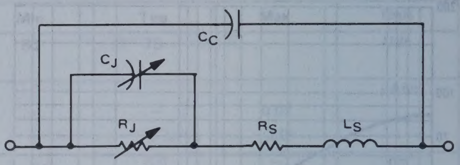
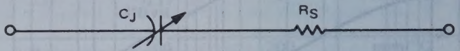


FIGURE 8



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Capacitance Ratio, CR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \qquad (1)$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \qquad (2)$$

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_SC_J$; and as ω^2 is increased from $1/L_SC_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_SC_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \qquad (3)$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \qquad (4)$$

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_c \approx 0.17$ pF

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \qquad (5)$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \qquad (6)$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2} \qquad (7)$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \qquad (8)$$

$$f_{co} = Qf_{max} \quad \frac{1}{2\pi R_S C_{BVR}} \qquad (9)$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with Motorola EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \quad \frac{f_{in}}{f_{co}} \qquad (10)$$

M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196

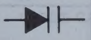
$$\text{Eff} = 1 - N \frac{f_{out}}{f_{co}} \qquad (11)$$

N(x2) = 20.8; N(x3) = 34.8; N(x4) = 62.5

M and N are Constants

MV2101 (SILICON)
thru
MV2115

VVC



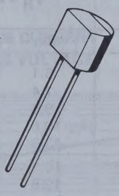
SILICON EPICAP DIODES

. . . designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance – 10%
- Complete Typical Design Curves

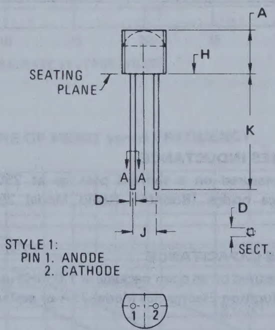
VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8–100 pF
30 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.45	4.70	0.175	0.185
D	0.41	0.48	0.016	0.019
J	2.29	2.79	0.090	0.110
K	12.70	–	0.500	

CASE 182-03

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current ($V_R = 25$ Vdc, $T_A = 25^oC$)	I_R	–	–	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF
Diode Capacitance Temperature Coefficient ($V_R = 4.0$ Vdc, f = 1.0 MHz)	TC_C	–	280	400	ppm/°C

	C_T, Diode Capacitance $V_R = 4.0$ Vdc, f = 1.0 MHz pF			Q, Figure of Merit $V_R = 4.0$ Vdc, f = 50 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		
Device	Min	Nom	Max	Min	Min	Typ	Max
MV2101	6.1	6.8	7.5	450	2.5	2.7	3.2
MV2102	7.4	8.2	9.0	450	2.5	2.8	3.2
MV2103	9.0	10.0	11.0	400	2.5	2.9	3.2
MV2104	10.8	12.0	13.2	400	2.5	2.9	3.2
MV2105	13.5	15.0	16.5	400	2.5	2.9	3.2
MV2106	16.2	18.0	19.8	350	2.5	2.9	3.2
MV2107	19.8	22.0	24.2	350	2.5	2.9	3.2
MV2108	24.3	27.0	29.7	300	2.5	3.0	3.2
MV2109	29.7	33.0	36.3	200	2.5	3.0	3.2
MV2110	35.1	39.0	42.9	150	2.5	3.0	3.2
MV2111	42.3	47.0	51.7	150	2.5	3.0	3.2
MV2112	50.4	56.0	61.6	150	2.6	3.0	3.3
MV2113	61.2	68.0	74.8	150	2.6	3.0	3.3
MV2114	73.8	82.0	90.2	100	2.6	3.0	3.3
MV2115	90.0	100.0	110.0	100	2.6	3.0	3.3

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO

TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. Q, FIGURE OF MERIT

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16".

6. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_C is guaranteed by comparing C_T at $V_R = 4.0$ Vdc, f = 1.0 MHz, $T_A = -65^oC$ with C_T at $V_R = 4.0$ Vdc, f = 1.0 MHz, $T_A = +85^oC$ in the following equation which defines TC_C:

$$TC_C = \frac{C_T(+85^oC) - C_T(-65^oC)}{85 + 65} \cdot \frac{10^6}{C_R(25^oC)}$$

Accuracy limited by measurement of C_T to ± 0.1 pF.

TYPICAL DEVICE PERFORMANCE

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE

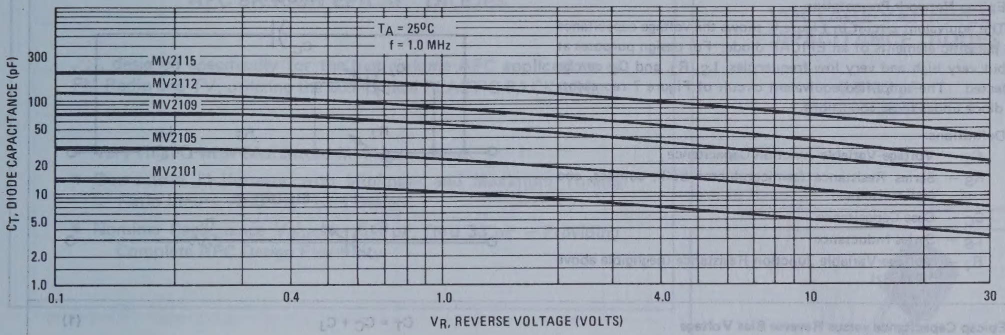


FIGURE 2 – NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

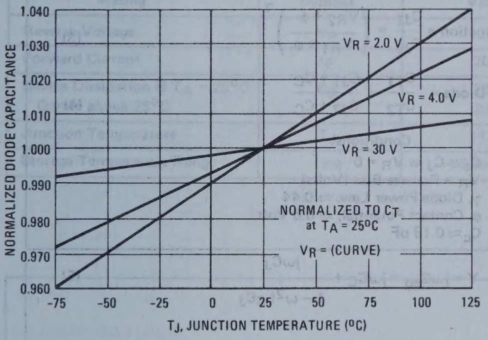


FIGURE 3 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

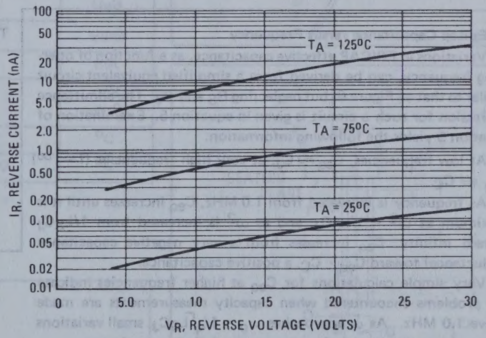


FIGURE 4 – FIGURE OF MERIT versus REVERSE VOLTAGE

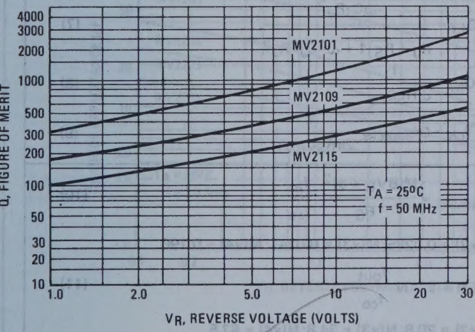
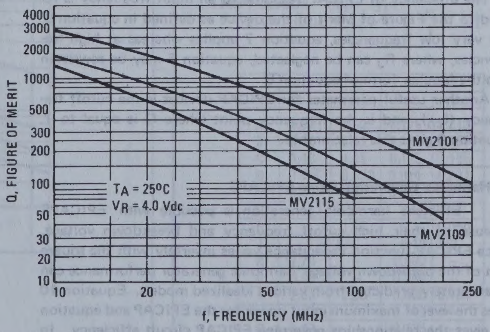


FIGURE 5 – FIGURE OF MERIT versus FREQUENCY



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 6 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 7 represents the diode under these conditions.

Definitions:

C_J – Voltage-Variable Junction Capacitance

R_S – Series Resistance (semiconductor bulk, contact, and lead resistance)

C_C – Case Capacitance

L_S – Series Inductance

R_J – Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 6

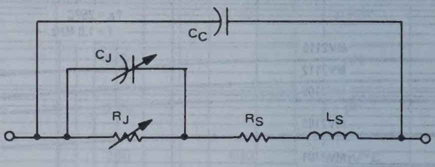
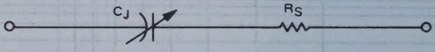


FIGURE 7



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \quad (1)$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \quad (2)$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \quad (3)$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \quad (4)$$

Conditions:

$C_o = C_J$ at $V_R = 0$

V_R = Reverse Bias (Volts)

γ, Diode Power Law, ≈ 0.44

ϕ, Contact Potential, ≈ 0.6 Volt

$C_c \approx 0.18$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 6, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies $(f \approx \infty)$ $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \quad (5)$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \quad (6)$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2)} \quad (7)$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \quad (8)$$

$$f_{co} = Qf_{meas} \approx \frac{1}{2\pi R_S C_{BVR}} \quad (9)$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \quad (10)$$

$M(x2) = 0.0285$; $M(x3) = 0.0241$; $M(x4) = 0.196$

$$\text{Eff} = 1 - N \frac{f_{out}}{f_{co}} \quad (11)$$

$N(x2) = 20.8$; $N(x3) = 34.8$; $N(x4) = 62.5$

M and N are Constants

MV2201, MV2203 (SILICON)
MV2205, MV2209

VVC

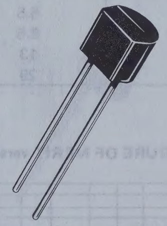
AFC SILICON EPICAP DIODES

. . . designed specifically for the high volume AFC applications of FM Radio and TV, utilizing the economical PLASTIC PACKAGE.

- Very High Q with Guaranteed Minimum Values
- Guaranteed Uniformity with Minimum and Maximum Tuning Ratio Limits, Assuring Fixed Design
- Nominal Capacitance Values – 6.8 pF Thru 33 pF – Providing Complete AFC Design Flexibility

VOLTAGE-VARIABLE CAPACITANCE DIODES

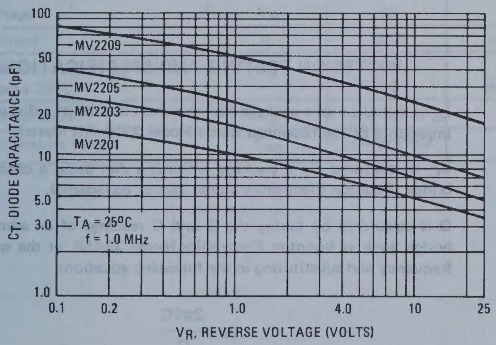
6.8–33 pF
25 VOLTS

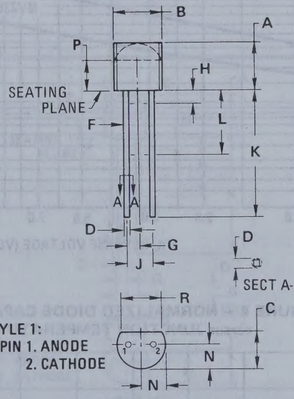


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	25	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

CASE 182-02

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic–All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10\ \mu Adc$)	BV_R	25		–	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, $T_A = 25^oC$) (V_R = 10 Vdc, $T_A = 85^oC$)	I_R	– –	– –	0.5 5.0	μAdc
Forward Voltage Drop ($I_F = 250\ \mu Adc$)	V_F	–	0.65	–	Vdc
Series Inductance (f = 250 MHz, lead length ≈ 1/16″)	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, lead length ≈ 1/16″)	C_C	–	0.18	–	pF

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF		Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	TR, Tuning Ratio C_1/C_{10} f = 1.0 MHz	
	Min	Max	Min	Min	Max
MV2201	5.5	8.0	300	1.9	2.3
MV2203	8.5	11.5	200	2.0	2.4
MV2205	13	17	200	2.1	2.5
MV2209	29	37	150	2.1	2.5

FIGURE 2 – FIGURE OF MERIT versus REVERSE VOLTAGE

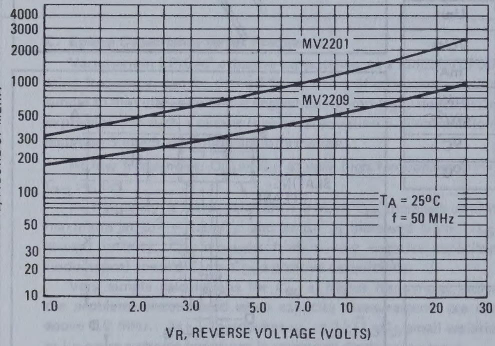


FIGURE 3 – FIGURE OF MERIT versus FREQUENCY

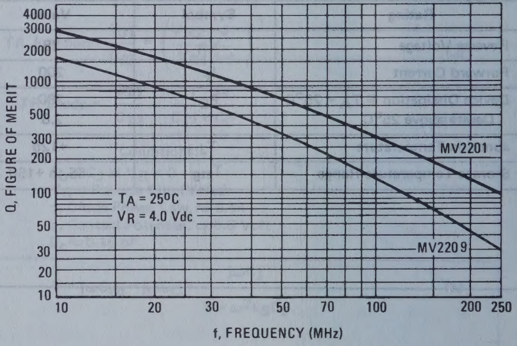
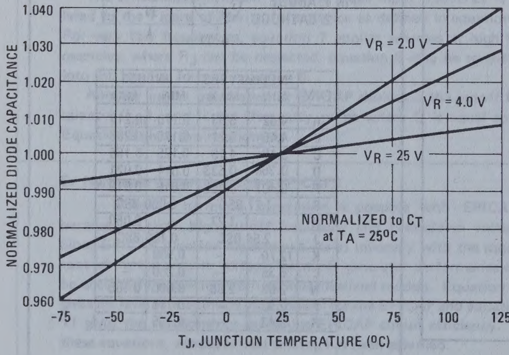


FIGURE 4 – NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



NOTES ON TESTING AND SPECIFICATIONS

L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

MV2301 (SILICON)
thru
MV2308

VVC

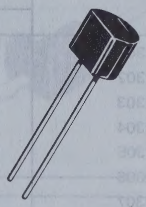
SILICON EPICAP DIODES

. . . epitaxial passivated tuning diodes designed for general tuning, trimming and AFC applications at low radio frequencies.

- Standard Capacitance Values to 330 pF
- Maximum Working Voltage of 20 V
- Excellent Q Factor at High Frequencies
- Guaranteed Minimum Q and Tuning Ratio
- Solid-State Reliability to Replace Mechanical Tuning Methods
- Low-Cost-Plastic Package for Economical Design

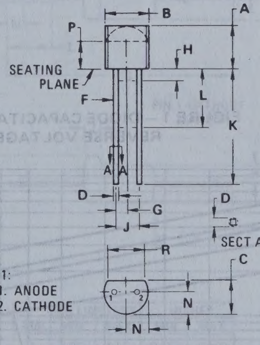
VOLTAGE-VARIABLE CAPACITANCE DIODES

120–330 pF
20 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Current	I_F	400	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	500 5.0	mW mW/^oC
Junction Temperature	T_J	+125	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC



STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

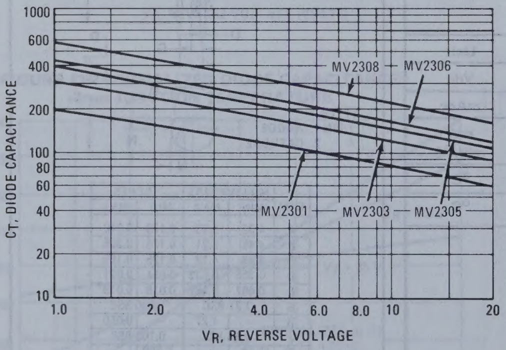
CASE 182-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	20	–	–	Vdc
Reverse Current (V_R = 15 Vdc)	I_R	–	–	0.1	μAdc
Series Inductance	L_S	–	6.0	–	nH
Case Capacitance	C_C	–	0.18	–	pF

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz			Q, Figure of Merit V_R = 4.0 Vdc, f = 20 MHz	Capacitance Ratio C_2/C_{20}
	Min	Nom	Max	Minimum	Minimum
MV2301	108	120	135	250	2.3
MV2302	132	150	165	250	2.3
MV2303	162	180	198	200	2.3
MV2304	180	200	220	200	2.3
MV2305	198	220	242	150	2.3
MV2306	225	250	275	150	2.3
MV2307	243	270	300	100	2.3
MV2308	297	330	363	100	2.3

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE



PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE:**
Determined from the self resonant frequency (ω_o) and the junction capacity of the device, C_J.

$$L_S = \frac{1}{\omega_o^2 C_J}$$

2. **C_T, DIODE CAPACITANCE:**
Measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent). ($C_T = C_C + C_J$).

3. **CAPACITANCE RATIO:**
The ratio of C_T measured at 2.0 Vdc divided by C_T measured at 20 Vdc.

4. **Q, FIGURE OF MERIT:**
Calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS9 with range extender or equivalent).

MV3102 (SILICON)
MV3103

VVC

SILICON EPICAP DIODES

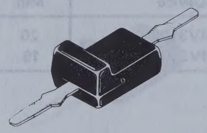
. . . designed in the new low-inductance Mini-L package for high volume requirements in VHF TV tuning, AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q With Guaranteed Minimum Values at VHF Frequencies
- Controlled and Uniform Tuning Ratio
- Low Inductance Mini-L Package
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance along the entire specified tuning range.

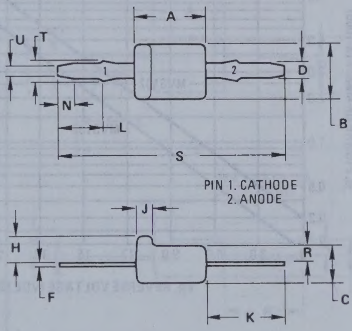
VOLTAGE VARIABLE CAPACITANCE DIODES

22 pF (Nominal)
30 VOLTS



MAXIMUM RATINGS

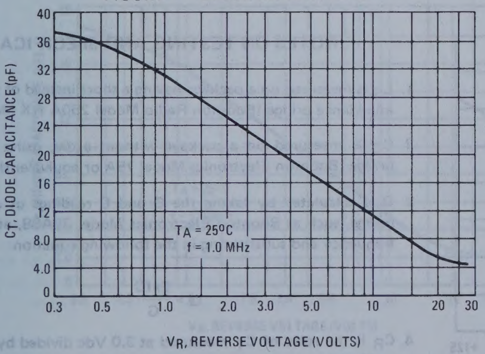
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

FIGURE 1 – DIODE CAPACITANCE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	–	–	0.1	μAdc
Series Inductance (f = 250 MHz, Measured at Lead Stop≈1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 3.0 Vdc f = 50 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz		Package Stripe
Device	Min	Nom	Max	Min	Min	Typ	Color
MV3102	20	22	25	300	4.5	4.8	Green
MV3103	19	–	26	200	4.0	–	White

FIGURE 2 – FIGURE OF MERIT

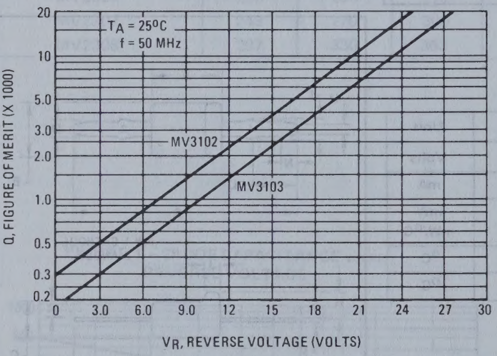


FIGURE 3 – LEAKAGE CURRENT

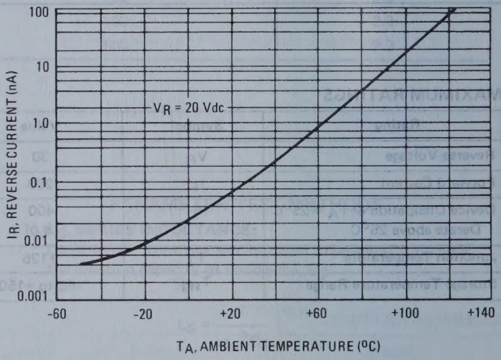
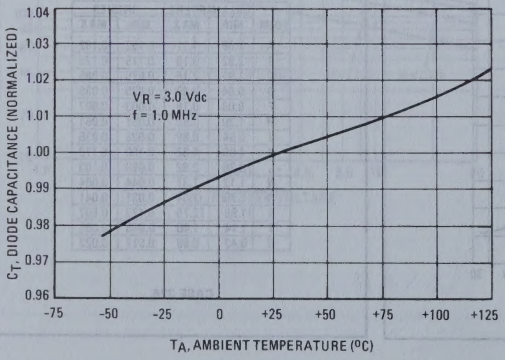


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

MV3140 (SILICON)
MV3141
MV3142

SILICON EPICAP DIODES

. . . designed in the new low-inductance mini-L package for high volume requirements of UHF and VHF TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

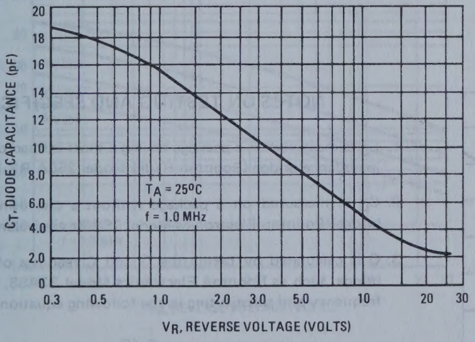
- Guaranteed Minimum Q Values at VHF and UHF Frequencies
- Controlled and Uniform Tuning Ratio
- Guaranteed Matching* Tolerance From Diode to Diode and Group to Group

*Upon request, diodes are available in matched sets of any number or in matched groups. All diodes in a set or group can be matched for capacitance to ±1.5% or 0.1 pF (whichever is greater) at all points along the specified tuning range.

MAXIMUM RATINGS

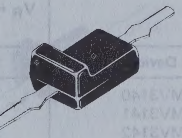
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

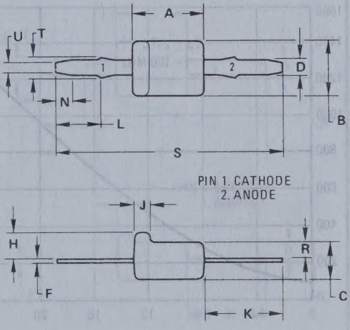
FIGURE 1 – DIODE CAPACITANCE



VOLTAGE VARIABLE CAPACITANCE DIODES

30 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic–All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	–	–	0.1	μAdc
Series Inductance (f = 250 MHz, Measured at Lead Stop ≈1/8″)	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF
Diode Capacitance Temperature Coefficient (V_R = 3.0 Vdc, f = 1.0 MHz)	TC_C	–	300	400	ppm/°C

	C_T, Diode Capacitance V_R = 3.0 Vdc V_R = 25 V pF		Q, Figure of Merit V_R = 3.0 Vdc f = 100 MHz	C_R, Capacitance Ratio C_3/C_{25} f = 1.0 MHz	Package Stripe
Device	Typ	Max	Min	Min	Color
MV3140 MV3141 MV3142	10.5 10.5 10.5	2.3 3.2 3.2	150 150 50	4.5 4.0 3.5	Blue White Orange

TYPICAL MV3140 ELECTRICAL CHARACTERISTICS

FIGURE 2 – FIGURE OF MERIT

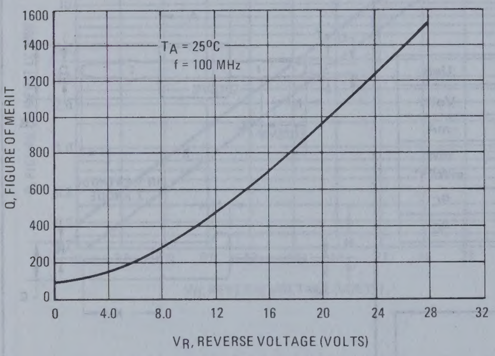


FIGURE 3 – LEAKAGE CURRENT

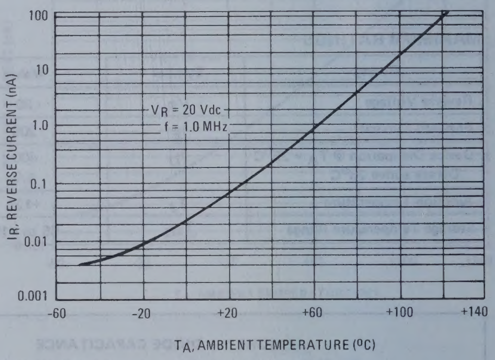
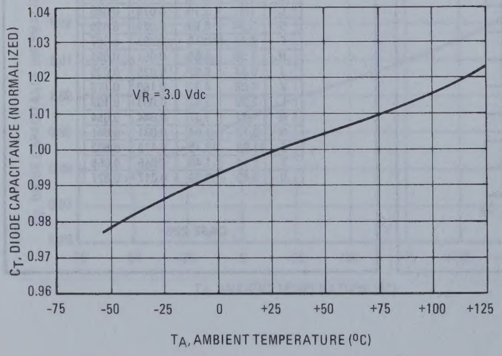


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 3.0 Vdc divided by C_T measured at 25 Vdc.

MV3501 (SILICON)
thru
MV3507

VVC

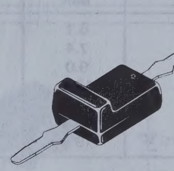
SILICON EPICAP DIODES

. . . designed in the new low-inductance Mini-L package for high-volume, low-cost frequency control and tuning applications; providing solid state reliability in replacement of mechanical tuning methods.

- High Q With Guaranteed Minimum Values @ 100 MHz
- Capacitance Values – 6.8 to 22 pF
- Ideal for RF and Microwave Applications
- Controlled and Uniform Capacitance Change

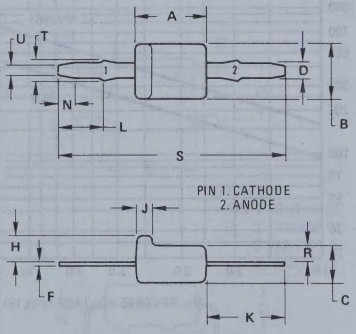
VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8–22 pF
30 VOLTS



MAXIMUM RATINGS

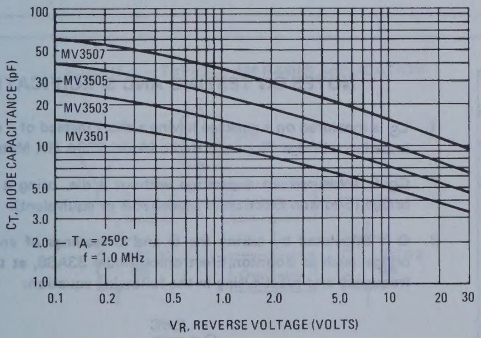
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 4.0	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	–65 to +150	°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.86	4.11	0.152	0.162
B	2.92	3.18	0.115	0.125
C	1.91	2.16	0.075	0.085
D	0.64	0.89	0.025	0.035
F	0.08	0.18	0.003	0.007
H	1.30	1.55	0.051	0.061
J	0.64	0.89	0.025	0.035
K	4.06	4.32	0.160	0.170
L	2.36	2.62	0.093	0.103
N	1.12	1.37	0.044	0.054
R	0.79	1.04	0.031	0.041
S	11.99	12.75	0.472	0.502
T	1.14	1.40	0.045	0.055
U	0.43	0.69	0.017	0.027

CASE 226

FIGURE 1 – DIODE CAPACITANCE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc) (V_R = 25 Vdc, T_A = 85°C)	I_R	 – –	 – –	 0.1 5.0	μAdc
Series Inductance (f = 250 MHz, measured at lead stop ≈1/8")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz)	C_C	–	0.1	–	pF

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 100 MHz	C_R, Capacitance Ratio C2/C30 f = 1.0 MHz	Package Stripe
Device	Min	Nom	Max	Min	Min	Color
MV3501	6.1	6.8	7.5	225	2.7	Brown
MV3502	7.4	8.2	9.0	225	2.8	Red
MV3503	9.0	10	11	200	2.8	Orange
MV3504	10.8	12	13.2	200	2.8	Yellow
MV3505	13.5	15	16.5	200	2.9	Green
MV3506	16.2	18	19.8	175	2.9	Blue
MV3507	19.8	22	24.2	175	2.9	Violet

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – FIGURE OF MERIT

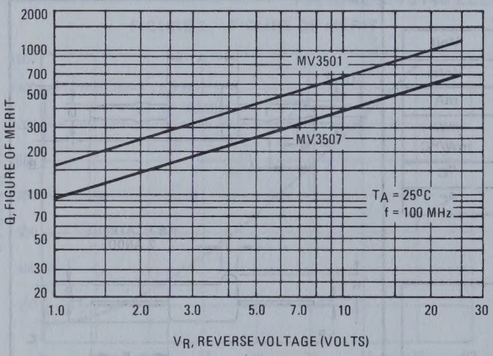


FIGURE 3 – FIGURE OF MERIT

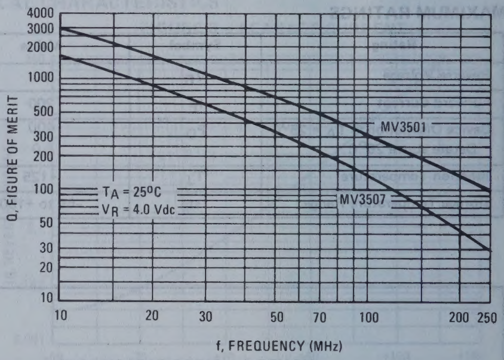
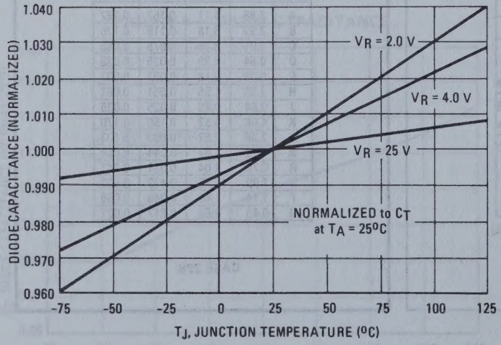


FIGURE 4 – DIODE CAPACITANCE



NOTES ON TESTING AND SPECIFICATIONS

1. L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).
2. C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

4. C_R is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

MVAM-1 (SILICON)

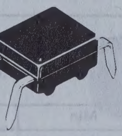
VVC

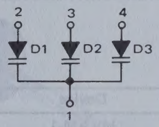
SILICON TUNING DIODE

. . . designed for electronic tuning of AM receivers, general frequency control or systems requiring two or three tightly matched voltage variable capacitance diodes. Supplied in a rugged four-pin dual in-line plastic package for the economical requirements of consumer and industrial applications.

- High Capacitance Ratio –
  C_R = 15 (Min) @ V_R = 1.0 Vdc to 25 Vdc
- Guaranteed Diode Capacitance –
  C_t = 400 pF (Min) -- 560 pF (Max) @ V_R = 1.0 Vdc, f = 1.0 MHz
- Ion Implanted Monolithic Triplet for Guaranteed ±1½% Matching Over Entire C-V Curve
- Guaranteed Figure of Merit –
  Q = 150 (Min) – 575 (Typ) @ V_R = 1.0 Vdc, f = 1.0 MHz

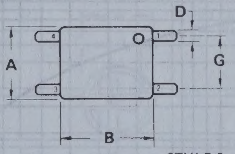
TRIPLE VOLTAGE VARIABLE CAPACITANCE DIODE FOR AM TUNING



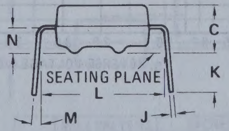


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	28	Volts
Forward Current	I_F	50	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 3.5	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +125	°C



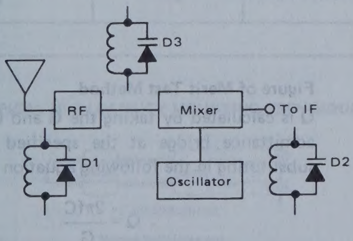
STYLE 2:
PIN 1. CATHODE
2. ANODE 1
3. ANODE 2
4. ANODE 3



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.21	5.59	0.205	0.220
B	6.60	7.11	0.260	0.280
C	3.43	4.06	0.135	0.160
D	0.63	0.89	0.025	0.035
G	3.94	4.19	0.155	0.165
J	0.20	0.30	0.008	0.012
K	2.54	3.56	0.100	0.140
L	9.02	9.27	0.355	0.365
M	–	10°	–	10°
N	1.14	1.40	0.045	0.055

CASE 206-02

FIGURE 1 – TYPICAL AM RADIO APPLICATION



Note: For optimum performance use D1 in the RF stage, D2 in the oscillator and D3 in the mixer.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, Each Device)

Characteristic — All Type		Symbol	Min	Typ	Max	Unit
Breakdown Voltage (I_R = 10 μAdc)		$V_{(BR)}$	28	—	—	Vdc
Reverse Current (V_R = 25 Vdc, T_A = 25°C)		I_R	—	—	150	nAdc
Diode Capacitance Temperature Coefficient (V_R = 1.0 Vdc, f = 1.0 MHz, T_A = -40°C to +85°C)		TC_C	—	435	—	ppm/°C
Case Capacitance		C_C				pF
	Leads 1-2		—	0.27	—	
	2-3		—	0.04	—	
	1-3		—	0.16	—	
	1-4		—	0.17	—	
	2-4		—	0.03	—	
	3-4		—	0.15	—	

	C_t, Diode Capacitance V_R = 1.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 1.0 Vdc f = 1.0 MHz		C_R, Capacitance Ratio C_1/C_{25} f = 1.0 MHz	
Device	Min	Typ	Max	Min	Typ	Min	Typ
MVAM-1	400	480	560	150	575	15	26

TYPICAL CHARACTERISTICS

FIGURE 2 — EFFECTS OF REVERSE VOLTAGE ON CAPACITANCE

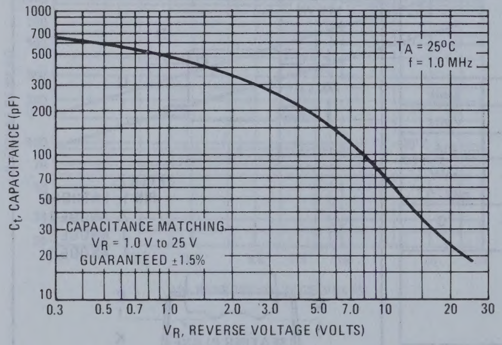


FIGURE 3 — EFFECTS OF TEMPERATURE ON CAPACITANCE

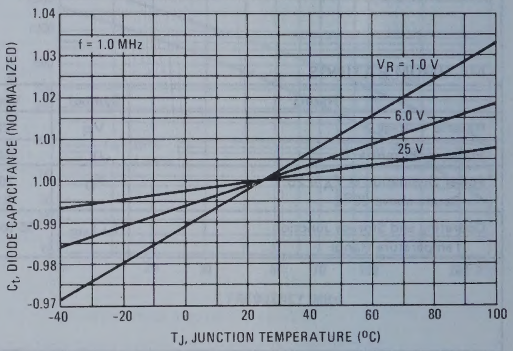


FIGURE 4 — FIGURE OF MERIT

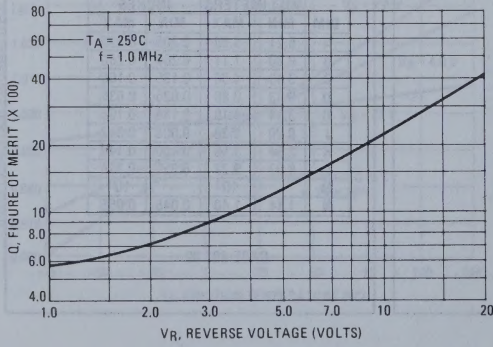


Figure of Merit Test Method

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equation :

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8 or equivalent).

MVI-2097 thru MVI-2109 (SILICON)

VVC

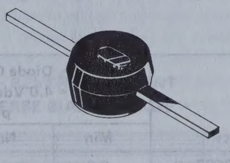
VOLTAGE-VARIABLE CAPACITANCE DIODES

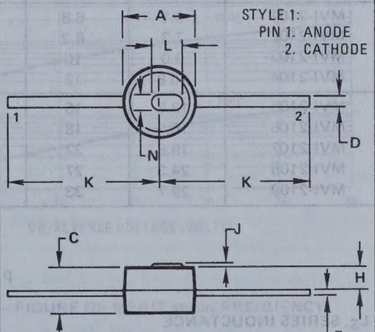
1.0 – 33 pF
30 VOLTS

SILICON EPICAP MICRO-I DIODES

. . . designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- Electrically Similar to MV2101 Series
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance – 10%
- Complete Typical Design Curves
- Supplied in Space Saving Micro-Miniature Package





STYLE 1:
PIN 1. ANODE
2. CATHODE

MAXIMUM RATINGS

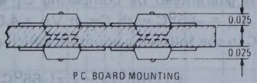
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	20	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	°C

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	1.98	2.34	0.078	0.092
C	1.22	1.47	0.048	0.058
D	0.25	0.41	0.010	0.016
F	0.10	0.15	0.004	0.006
H	0.51	0.76	0.020	0.030
J	0.03	0.08	0.001	0.003
K	4.19	4.45	0.165	0.175
L	0.89	1.14	0.035	0.045
N	0.38	0.64	0.015	0.025

Optional Package with Raised Circular Tab Available; Specify Case 166-01.

CASE 166-02

TYPICAL HIGH DENSITY MOUNTING TECHNIQUE



P C BOARD MOUNTING

Maximum Solder Temperature:
250°C for 10s

MVI-2097 thru MVI-2109 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc)	I_R	–	–	20	nAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	3.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.15	–	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	–	280	400	ppm/°C

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc f = 100 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Color Code	
	Min	Nom	Max	Min	Min	Max	Top	Bottom
MVI-2097	0.8	1.0	1.2	325	2.0	2.4	None	None
MVI-2098	1.8	2.2	2.7	325	2.0	2.8	None	Brown
MVI-2099	2.6	3.3	4.0	300	2.2	2.9	None	Red
MVI-2100	3.7	4.7	5.7	300	2.4	2.9	None	Orange
MVI-2101	6.1	6.8	7.5	275	2.5	3.3	None	Yellow
MVI-2102	7.3	8.2	9.0	275	2.6	3.3	None	Green
MVI-2103	9.0	10	11	275	2.6	3.3	None	Blue
MVI-2104	10.8	12	13.2	275	2.6	3.3	None	Violet
MVI-2105	13.5	15	16.5	275	2.6	3.3	None	Gray
MVI-2106	16.2	18	19.8	250	2.7	3.3	None	White
MVI-2107	19.8	22	24.2	200	2.7	3.3	Brown	None
MVI-2108	24.3	27	29.7	200	2.7	3.3	Brown	Brown
MVI-2109	29.7	33	36.3	200	2.7	3.3	Brown	Red

PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE**
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. **C_C, CASE CAPACITANCE**
C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. **C_T, DIODE CAPACITANCE**
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. **TR, TUNING RATIO**
TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. **Q, FIGURE OF MERIT**
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16"

6. **TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT**
TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \frac{C_T(+85^{\circ}C) - C_T(-65^{\circ}C)}{85 + 65} \cdot \frac{10^6}{C_R(25^{\circ}C)}$$

Accuracy limited by measurement of C_T to ± 0.1 pF.
C_R = Capacitance at V_R = 4.0 Vdc

TYPICAL CHARACTERISTICS

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

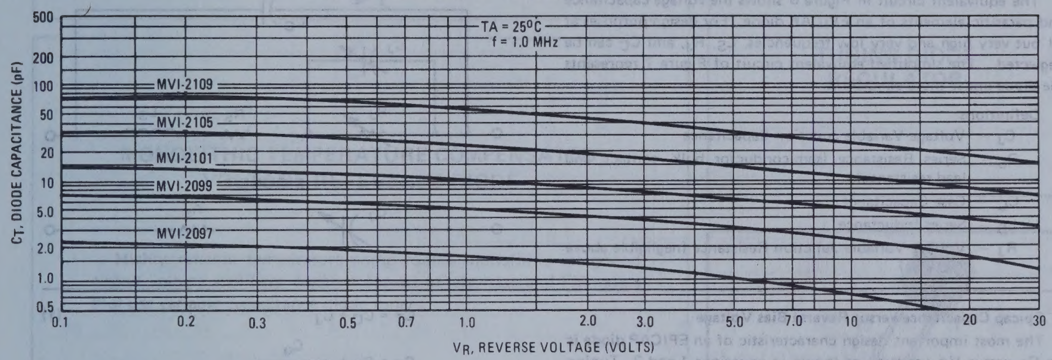


FIGURE 2 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

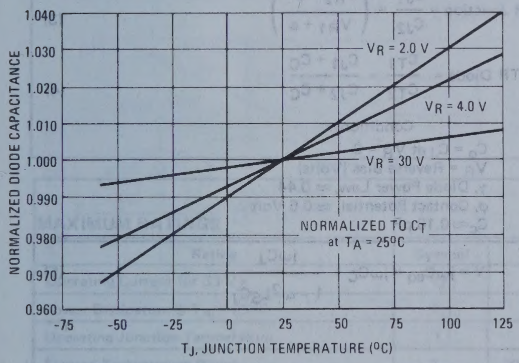


FIGURE 3 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

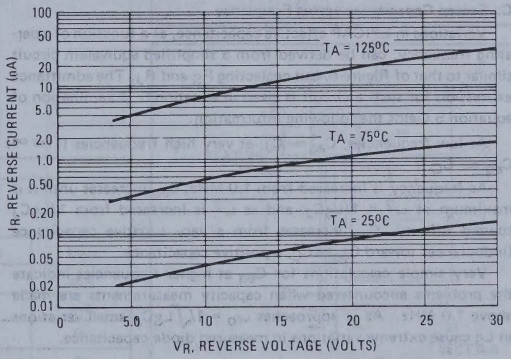


FIGURE 4 — FIGURE OF MERIT versus REVERSE VOLTAGE

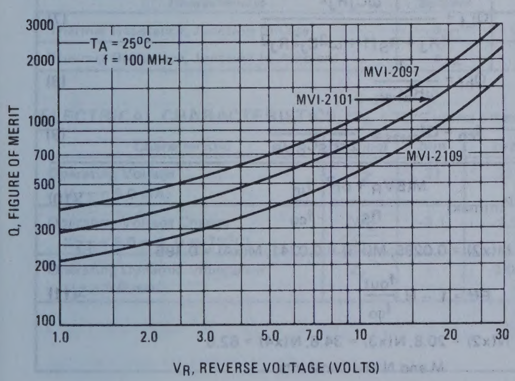
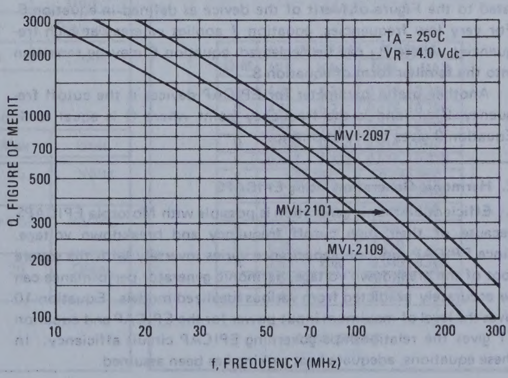


FIGURE 5 — FIGURE OF MERIT versus FREQUENCY



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 6 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 7 represents the diode under these conditions.

Definitions:

C_J — Voltage-Variable Junction Capacitance
R_S — Series Resistance (semiconductor bulk, contact, and lead resistance)
C_C — Case Capacitance
L_S — Series Inductance
R_J — Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 6

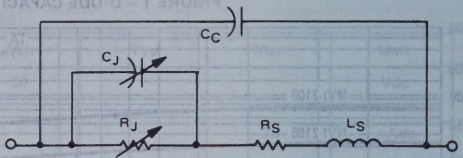
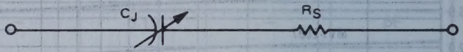


FIGURE 7



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \tag{2}$$

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 6, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_SC_J$; and as ω^2 is increased from $1/L_SC_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_SC_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \tag{3}$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \tag{4}$$

Conditions:

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_c \approx 0.18$ pF

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{5}$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{6}$$

$$Q_{Lf} = \frac{\omega C_J R_J{}^2}{R_J + R_S(1 + \omega^2 C_J{}^2 R_J{}^2} \tag{7}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{8}$$

$$f_{co} = Qf_{meas} \approx \frac{1}{2\pi R_S C_{BVR}} \tag{9}$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with Motorola EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \; \frac{f_{in}}{f_{co}} \tag{10}$$

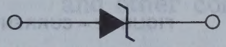
$M(x2) = 0.0285$; $M(x3) = 0.0241$; $M(x4) = 0.196$

$$Eff = 1 - N \frac{f_{out}}{f_{co}} \tag{11}$$

$N(x2) = 20.8$; $N(x3) = 34.8$; $N(x4) = 62.5$

M and N are Constants

MVS460

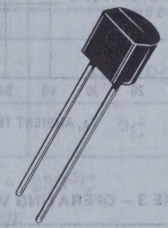


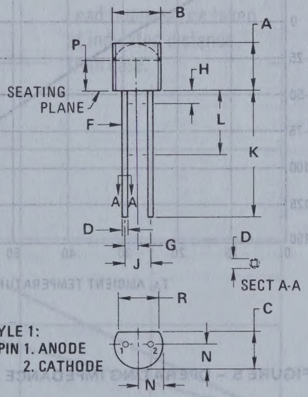
MONOLITHIC TEMPERATURE COMPENSATED VOLTAGE REFERENCE DIODE

Highly reliable temperature compensated monolithic integrated circuit voltage stabilizer designed for use in television and FM radios that use variable capacitance diode tuners.

- Low Dynamic Operating Impedance
- Low Operating Voltage Change over Temperature Range

TUNING DIODE REGULATOR





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.21	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.356	0.533	0.014	0.021
F	0.407	0.482	0.016	0.019
G	1.27 BSC		0.050 BSC	
H	–	1.27	–	0.050
J	2.54 BSC		0.100 BSC	
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	2.03	2.66	0.080	0.105
P	2.93	–	0.115	–
R	3.43	–	0.135	–

CASE 182-02

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Operating Current for 33 V_Z	I_Z	18	mA
Power Dissipation @ $T_A = 25^oC$	P_D	625	mW
Operating Junction Temperature	T_J	150	^oC
Storage Temperature Range	T_{stg}	-40 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.083	$^oC/mW$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.200	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Operating Voltage ($I_{ZT} = 5.0$ mA)	V_Z	31	33	35	Volts
Operating Voltage Change ($I_{ZT} = 5.0$ mA, 0 to 70^oC)	$\frac{\Delta V_Z}{\Delta T}$	-3.1	-2.3	+1.55	$mV/^oC$
Operating Dynamic Impedance ($I_Z = 5.0$ mA)	Z_z	–	9.0	25	Ohms

FIGURE 1 – POWER DERATING

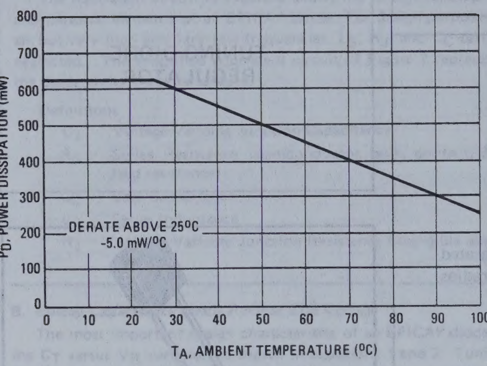


FIGURE 2 – CURRENT DERATING

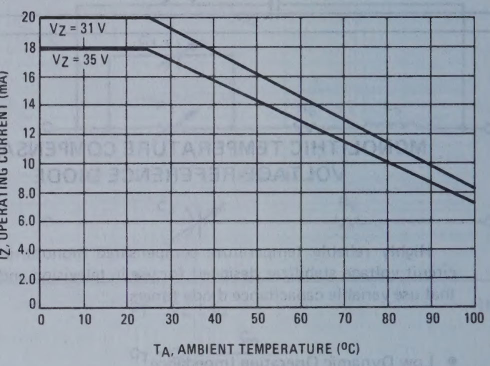


FIGURE 3 – OPERATING VOLTAGE CHANGE

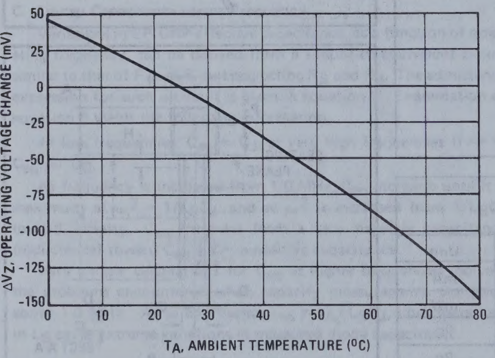
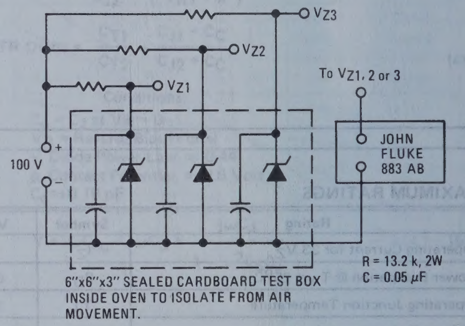
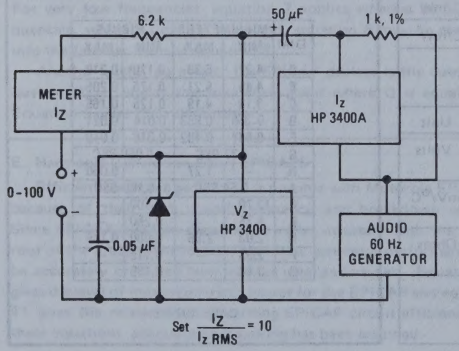


FIGURE 4 – OPERATING VOLTAGE CHANGE TEST CIRCUIT



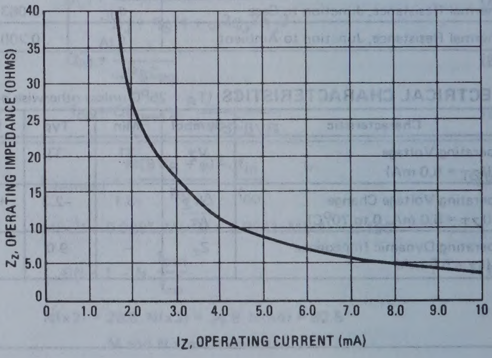
V_Z3
V_Z2
V_Z1
To V_Z1, 2 or 3
+
100 V
−
JOHN
FLUKE
883 AB
R = 13.2 k, 2W
C = 0.05 µF
6"x6"x3" SEALED CARDBOARD TEST BOX
INSIDE OVEN TO ISOLATE FROM AIR
MOVEMENT.

FIGURE 5 – OPERATING IMPEDANCE TEST CIRCUIT

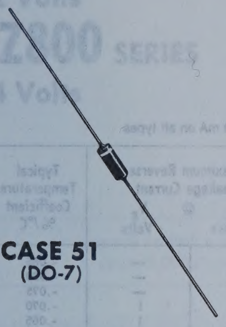


6.2 k
50 µF
+
1 k, 1%
METER
I_Z
I_z
HP 3400A
+
0-100 V
−
V_z
HP 3400
0.05 µF
AUDIO
60 Hz
GENERATOR
Set I_Z / I_z RMS = 10

FIGURE 6 – OPERATING IMPEDANCE



MZ500-1 thru **MZ500-40** (SILICON)



CASE 51
(DO-7)

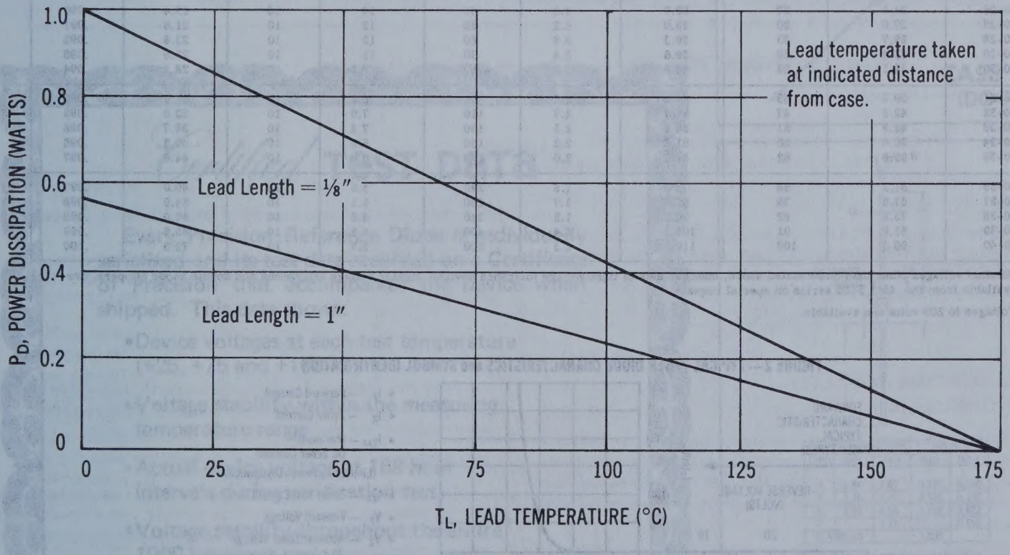
Miniature plastic encapsulated zener diodes for regulated power supply circuits, surge protection, arc suppression and other functions in television, automotive and other consumer product applications.

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation @ T_L = 50°C	400	mW
Derate above 50°C	3.2	mW/°C
Junction Temperature*	-65 to +175	°C

*Maximum lead temperature for 10 seconds at 1/16'' from case = 230°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.42 gram (approximately).

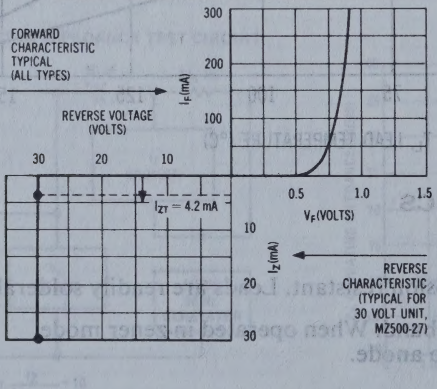
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) V_F = 1.5 V max @ 200 mA on all types

Type No.	Zener Voltage V_Z @ I_{ZT} Volts*			Test Current I_{ZT} mA	Typical Z_{ZT} @ I_{ZT} Ohms	Max DC Zener Current I_{ZM} mA	Maximum Reverse Leakage Current		Typical Temperature Coefficient %/°C
	Min	Nom	Max				I_R @ μA Max	V_R Volts	
MZ500-1	2.16	2.4	2.64	20	35	150	—	—	-.085
MZ500-2	2.43	2.7	2.94	20	30	135	—	—	-.080
MZ500-3	2.7	3.0	3.3	20	30	120	—	—	-.075
MZ500-4	2.97	3.3	3.63	20	30	110	20	1	-.070
MZ500-5	3.24	3.6	3.96	20	25	100	20	1	-.065
MZ500-6	3.51	3.9	4.29	20	25	95	20	1	-.060
MZ500-7	3.87	4.3	4.73	20	25	85	5	1	-.050
MZ500-8	4.23	4.7	5.17	20	20	80	5	1	-.043
MZ500-9	4.59	5.1	5.61	20	20	70	5	1	±.030
MZ500-10	5. 04	5.6	6.16	20	15	65	5	1	±.028
MZ500-11	5.58	6.2	6.82	20	10	60	5	1	+.045
MZ500-12	6.12	6.8	7.48	20	5	55	5	1	.050
MZ500-13	6.75	7.5	8.25	20	10	50	5	1	.058
MZ500-14	7.38	8.2	9.02	20	10	45	5	1	.062
MZ500-15	8.19	9.1	10.02	20	10	40	5	1	.068
MZ500-16	9.0	10	11.0	20	20	36	5	1	.075
MZ500-17	9.9	11	12.1	20	20	35	5	1	.076
MZ500-18	10.8	12	13.2	20	30	32	5	1	.077
MZ500-19	11.7	13	14.3	9.5	15	30	10	9.4	.079
MZ500-20	13.5	15	16.5	8.5	20	26	10	10.8	.082
MZ500-21	14.4	16	17.6	7.8	20	25	10	11.5	.083
MZ500-22	16.2	18	19.8	7.0	25	21	10	13.0	.085
MZ500-23	18.0	20	22.0	6.2	30	19	10	14.4	.086
MZ500-24	19.8	22	24.2	5.6	30	17	10	15.8	.087
MZ500-25	21.6	24	26.4	5.2	35	16	10	17.3	.088
MZ500-26	24.3	27	29.7	4.6	45	14	10	19.4	.090
MZ500-27	27.0	30	33.0	4.2	50	13	10	21.6	.091
MZ500-28	29.7	33	36.3	3.8	60	12	10	23.8	.092
MZ500-29	32.4	36	39.6	3.4	70	11	10	25.9	.093
MZ500-30	35.1	39	42.9	3.2	80	9.1	10	28.1	.094
MZ500-31	38.7	43	47.3	3.0	95	8.8	10	31.0	.095
MZ500-32	42.3	47	51.7	2.7	110	7.9	10	33.8	.095
MZ500-33	45.9	51	56.1	2.5	130	7.4	10	36.7	.096
MZ500-34	50.4	56	61.6	2.2	150	6.9	10	40.3	.096
MZ500-35	55.8	62	68.2	2.0	190	6.0	10	44.6	.097
MZ500-36	61.2	68	74.8	1.8	240	5.5	10	49.0	.097
MZ500-37	67.5	75	82.5	1.7	280	5.1	10	54.0	.098
MZ500-38	73.8	82	90.2	1.5	340	4.6	10	59.0	.098
MZ500-39	81.9	91	100.1	1.4	400	4.2	10	65.5	.099
MZ500-40	90.0	100	110.0	1.3	500	3.7	10	72.0	.100

*1. Nominal voltages other than those stated above, matched sets of tight voltage tolerance devices, tighter voltage tolerances and double anode clippers, are available from the .4M3.3ZS5 series on special request.

2. Voltages to 200 volts are available.

FIGURE 2 — TYPICAL ZENER DIODE CHARACTERISTICS and SYMBOL IDENTIFICATION



- I_F — Forward Current
- I_Z — Zener Current
- I_{ZM} — Maximum DC Zener Current (Limited by Power Dissipation)
- I_{ZT} — Zener Test Current
- V_F — Forward Voltage
- V_Z — Nominal Zener Voltage
- Z_Z — Zener Impedance
- Z_{ZT} — Zener Impedance at Test Current (I_{ZT})

MZ600 SERIES (SILICON)

6.2 Volts

MZ800 SERIES

8.4 Volts

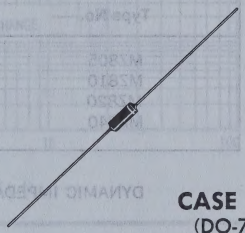
PRECISION REFERENCE DIODES

. . . designed, manufactured and tested for applications requiring a precision voltage reference with ultra-high stability of voltage with time and temperature change.

Special test laboratory uses precision measurement equipment, four-terminal (separate contacts for current and voltage) measurement techniques and voltage standards to provide calibration directly traceable to the National Bureau of Standards.

PRECISION REFERENCE DIODES

with
CERTIFIED
ZENER VOLTAGE-TIME
STABILITY

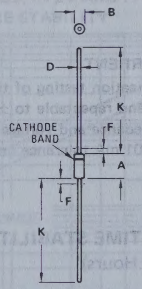


CASE 51
(DO-7)

Certified TEST DATA

Every Precision Reference Diode is individually serialized and its test data recorded on a Certificate of Precision that accompanies the device when shipped. This data shows:

- Device voltages at each test temperature (+25, +75 and +100°C)
- Voltage stability within the measuring temperature range
- Actual device voltage at 168 hour intervals during verification test
- Voltage stability throughout the entire 1000 hour test period
- Certification of Precision
- All diodes are marked with the device type number and polarity band



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F		1.27		0.050
K	25.40		1.000	

All JEDEC dimensions and notes apply

CASE 51-02

DO-204AA

MECHANICAL CHARACTERISTICS:

Case:
Glass, Hermetically Sealed

Leads: Dumet

Lead Finish:
Nickel 50-100 μin. then gold plated 50-200 μin.

Weight:
0.2 grams (approx)

OPERATING TEMPERATURE RANGE:* 25 to 100°C.

MZ600 SERIES (Voltage 6.2V ± 5%, I_{ZT} = 7.5 mAdc †, ΔV_Z = 2.5 mVdc)**

Type No.	Voltage-Time Stability (μV/1000 Hours)	Parts Per Million Change (ppm/1000 Hours)
MZ605	30 Maximum	< 5
MZ610	60 Maximum	<10
MZ620	120 Maximum	<20
MZ640	240 Maximum	<40

DYNAMIC IMPEDANCE: 10 ohms at I_{ZT} = 7.5 mAdc, I_{ac} = 0.75 mA.

MZ800 SERIES (Voltage 8.4V ± 5%, I_{ZT} = 10 mAdc†, ΔV_Z = 3.5 mVdc)**

Type No.	Voltage-Time Stability (μV/1000 Hours)	Parts Per Million Change (ppm/1000 Hours)
MZ805	45 Maximum	< 5
MZ810	90 Maximum	<10
MZ820	180 Maximum	<20
MZ840	360 Maximum	<40

DYNAMIC IMPEDANCE: 15 ohms at I_{ZT} = 10 mAdc, I_{ac} = 1.0 mA.

NOTES

†TEST CURRENT
For certification testing of time stability, Motorola maintains I_{ZT} constant and repeatable to ±0.05 μA tolerance. For voltage tolerance, impedance and voltage temperature stability I_{ZT} needs to be held to 0.01 mA tolerance only.

*Maximum limits for use as a precision reference device. Limits are well below the maximum thermal limits.

**VOLTAGE-TEMPERATURE STABILITY: Maximum allowable voltage change between voltages recorded at 25, 75 and 100° C ambient.

VOLTAGE-TIME STABILITY
(ΔV_Z/1000 Hours).

The device voltage is read and recorded initially and at 168 hour intervals through 1000 hours. The maximum change of voltage between readings, taken at any of the seven points, must be less than the maximum voltage change per 1000 hours specified as Voltage-Time Stability.

TURN-ON CHARACTERISTICS

Precision Reference Diodes have been tested to determine the behavior of the device under interrupted power operation.

To insure specified performance, adequate time must be allowed for the device and its environment to reach thermal equilibrium. "Warm-up" time may range from 10 to 30 minutes. Thermal equilibrium is reached when the chamber is cycling at the required temperature with the device energized.

After this "warm-up" period, the device voltage will be between the minimum and the maximum voltage of those recorded at the seven points of the Voltage-Time Stability certification.

MOUNTING

Excellent results have been obtained by using a mechanical mounting. If necessary, the device may be soldered into a circuit using a heat sink between the heat source and the body of the diode. A low thermal EMF solder is recommended.

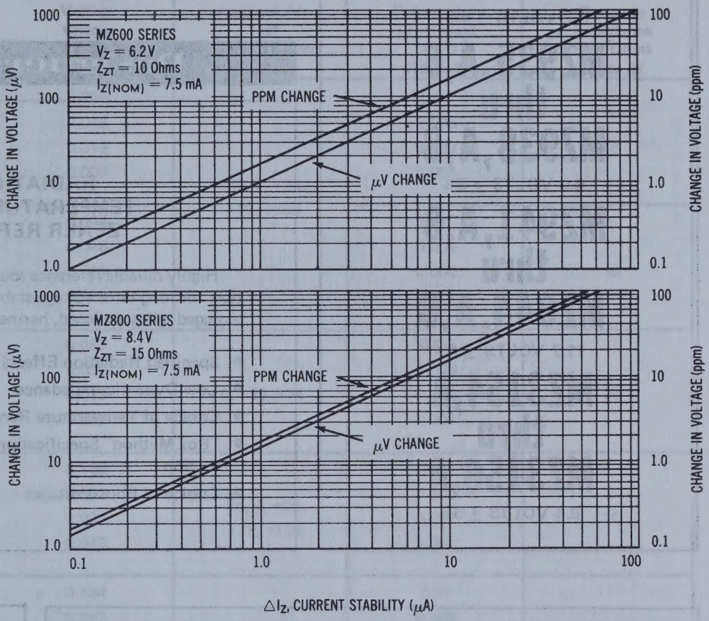
SPECIAL NOTE

Voltage tolerance less than 5.0% is available upon special request. Precision Reference Diodes capable of meeting special requirements for standard voltages regardless of required test current, temperature range, or test temperatures are available. Custom requirements of particular devices for specific applications are also available.

VOLTAGE-CURRENT STABILITY CHARACTERISTICS

For verification of time stability, and for repeatable operation, I_{ZT} should be maintained with a tolerance of ±0.1 μA. Figure 1 will assist in design where the supply current stability cannot be maintained to better than 0.2 μA deviation.

FIGURE 1 – MAXIMUM VOLTAGE CHANGE, IN μV AND PPM, DUE TO CURRENT SUPPLY STABILITY



VOLTAGE-TEMPERATURE CHARACTERISTICS

CHOICE OF OPERATING TEMPERATURE

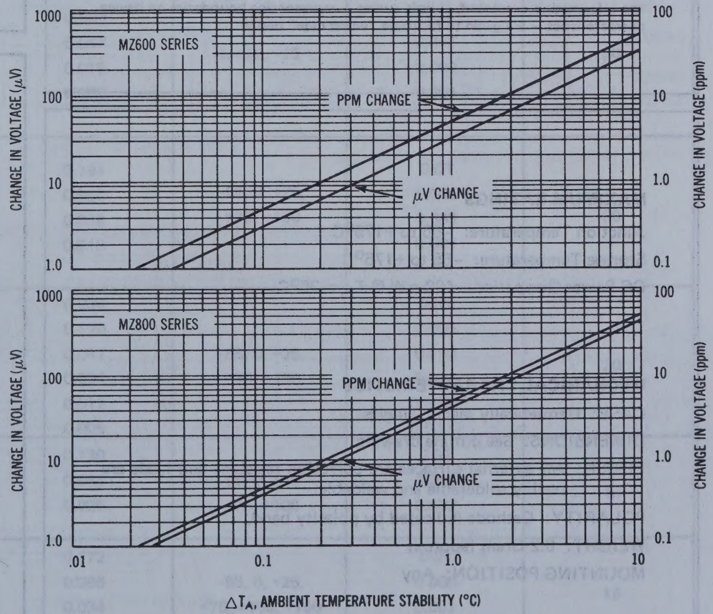
The stability certification is performed at 65°C ± 0.02°C. The operating temperature can be selected within the operating temperature range. If the desired temperature is not 65°C, the precise voltage of the device will be different but the certified stability will still be observed.

VOLTAGE TEMPERATURE STABILITY

For verification of time stability and/or repeatable operation, the ambient temperature should be controlled to ±0.1°C.

Figure 2 will assist in designs where ambient temperature cannot be controlled to better than 0.2°C deviation.

FIGURE 2 – TYPICAL VOLTAGE CHANGE, IN μV AND PPM, DUE TO AMBIENT TEMPERATURE STABILITY



MZ821,A
MZ823,A
MZ825,A
MZ827,A

6.2 VOLTS ± 5%

MZ935,A,B
thru
MZ938,A,B

9.0 VOLTS ± 5%

MZ941,A,B
thru
MZ944,A,B

11.7 VOLTS ± 5%

MZ3154,A
thru
MZ3156,A

8.4 VOLTS ± 5%

Designers Data Sheet

RADIATION HARDENED TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. Ramrod construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Specified Radiation Effects
- Low Dynamic Impedance
- Choice of Temperature Ranges
- "Box Method" Specifications Guarantee Maximum Voltage Deviation
- Choice of Four Voltages

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Junction Temperature: −55 to +175°C

Storage Temperature: −65 to +175°C

DC Power Dissipation: 400 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing

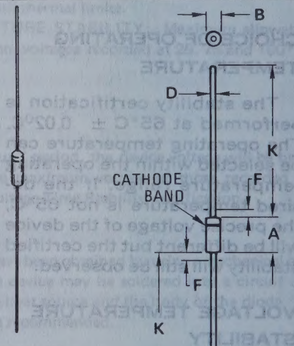
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

RADIATION HARDENED TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES



CASE 51-02
DO-204AA

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

MZ821,A, MZ823,A, MZ825,A, MZ827,A, MZ935,A,B thru MZ938,A,B, MZ941,A,B thru MZ944,A,B, MZ3154,A thru MZ3156,A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Reference Voltage at Test Current	Motorola Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Air Test Temperatures °C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} Ohms (Note 3)
V_Z = 6.2 V ± 5% @ I_{ZT} = 7.5 mA	MZ821	0.096	-55, 0, +25, +75, +100	0.01	15
	MZ823	0.048		0.005	
	MZ825	0.019		0.002	
	MZ827	0.009		0.001	
	MZ821A	0.096		0.01	10
	MZ823A	0.048		0.005	
	MZ825A	0.019		0.002	
	MZ827A	0.009		0.001	
V_Z = 9.0 V ± 5% @ I_{ZT} = 7.5 mA	MZ935	0.067	0, +25, +75	0.01	20
	MZ936	0.033		0.005	
	MZ937	0.013		0.002	
	MZ938	0.006		0.001	
	MZ935A	0.139	-55, 0, +25, +75, +100	0.01	20
	MZ936A	0.069		0.005	
	MZ937A	0.027		0.002	
	MZ938A	0.013		0.001	
	MZ935B	0.184	-55, 0, +25, +75, +100, +150	0.01	20
	MZ936B	0.092		0.005	
	MZ937B	0.037		0.002	
	MZ938B	0.018		0.001	
V_Z = 11.7 V ± 5% @ I_{ZT} = 7.5 mA	MZ941	0.088	0, +25, +75	0.01	30
	MZ942	0.044		0.005	
	MZ943	0.018		0.002	
	MZ944	0.009		0.001	
	MZ941A	0.181	-55, 0, +25, +75, +100	0.01	30
	MZ942A	0.090		0.005	
	MZ943A	0.036		0.002	
	MZ944A	0.018		0.001	
	MZ941B	0.239	-55, 0, +25, +75, +150	0.01	30
	MZ942B	0.120		0.005	
	MZ943B	0.047		0.002	
	MZ944B	0.024		0.001	
	MZ945B	0.012		0.0005	
	MZ946B	0.005		0.0002	
V_Z = 8.4 V ± 5% @ I_{ZT} = 10 mA	MZ3154	0.130	-55, 0, +25 +75, +100	0.01	15
	MZ3155	0.065		0.005	
	MZ3156	0.026		0.002	
	MZ3154A	0.172	-55, 0, +25, +75, +100, +150	0.01	15
	MZ3155A	0.086		0.005	
	MZ3156A	0.034		0.002	

EFFECTS OF NEUTRON DOSAGE

FIGURE 1 – EFFECT OF NEUTRON DOSAGE ON REFERENCE VOLTAGE

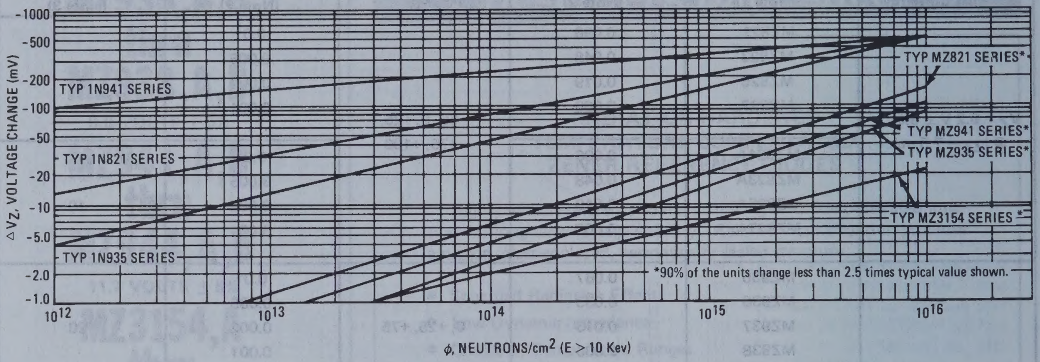
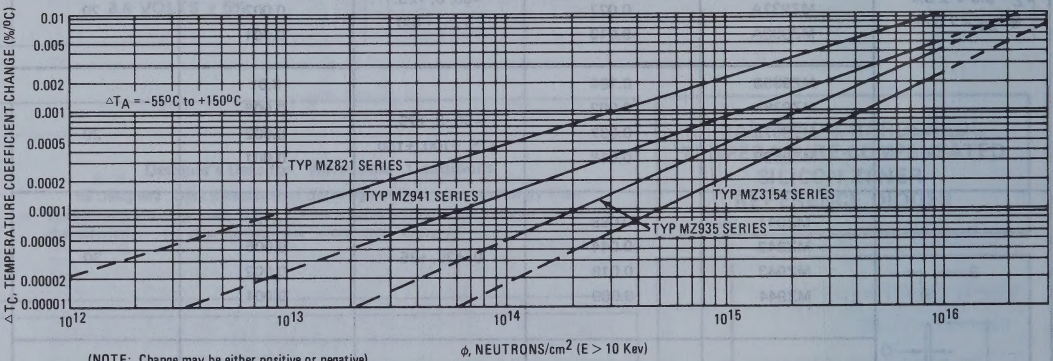


FIGURE 2 – TYPICAL EFFECT OF NEUTRON DOSAGE ON TEMPERATURE COEFFICIENT



(NOTE: Change may be either positive or negative)

FIGURE 3 – EFFECT OF NEUTRON DOSAGE ON IMPEDANCE

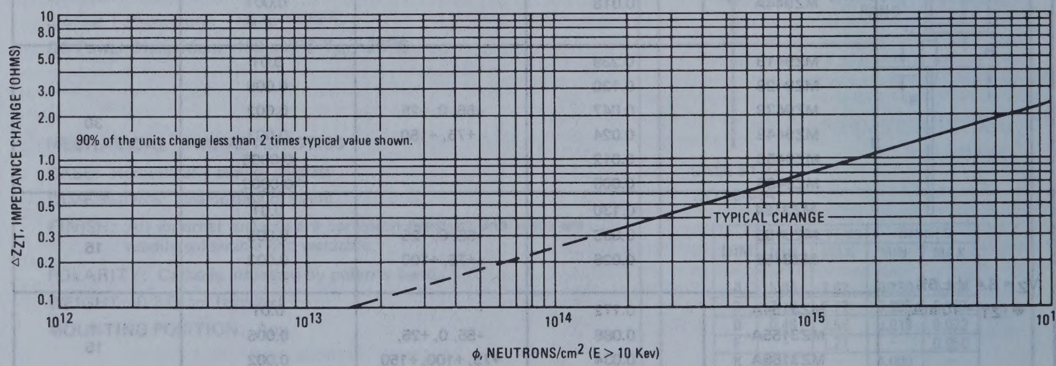
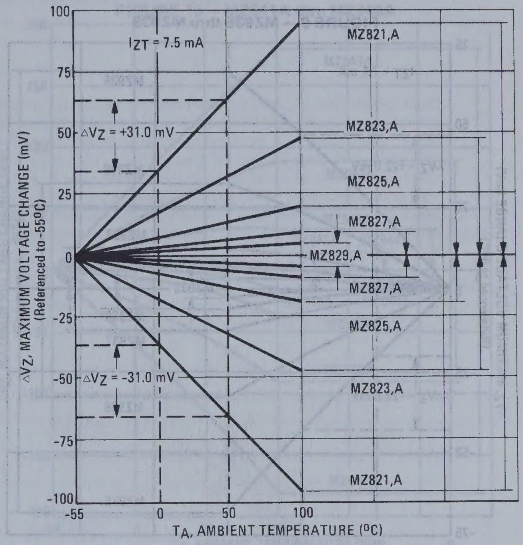


FIGURE 4
MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE
(with I_{ZT} = 7.5 mA ± 0.01 mA)

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +31 mV or -31 mV for MZ821 or MZ821A, as illustrated by the dashed lines in Figure 4. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N821,A, 1N823,A, 1N825,A, 1N827,A, 1N829,A.

The maximum voltage change, ΔV_Z, in Figures 5 and 6 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 5 or 6 to the ΔV_Z in Figure 4 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 5 or 6 on Figure 4.



ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE

(At Specified Temperatures) (See Note 5)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES

FIGURE 5 – MZ821 SERIES

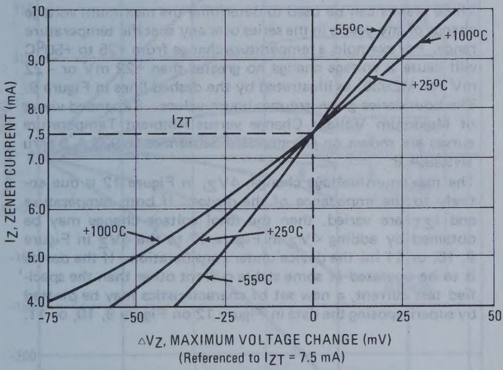
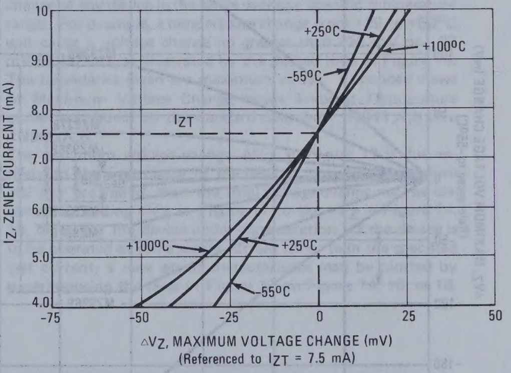


FIGURE 6 – MZ821A SERIES



MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES

FIGURE 7 – MZ821 SERIES

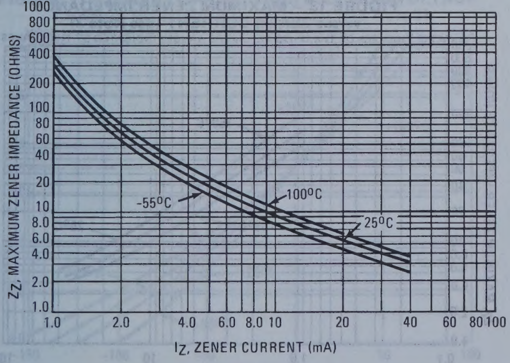
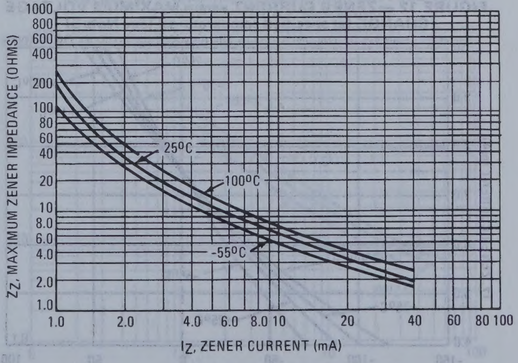


FIGURE 8 – MZ821A SERIES



MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(With I_{ZT} = 7.5 mA ± 0.01 mA)

FIGURE 9 – MZ935 thru MZ939

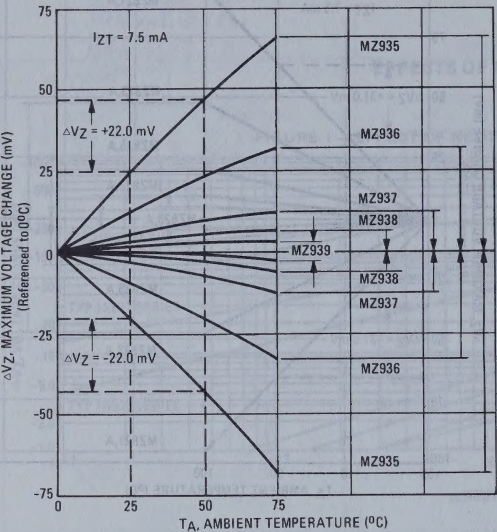


FIGURE 10 – MZ935A thru MZ939A

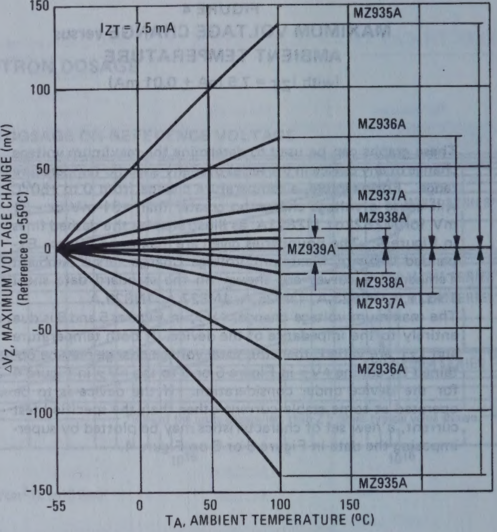
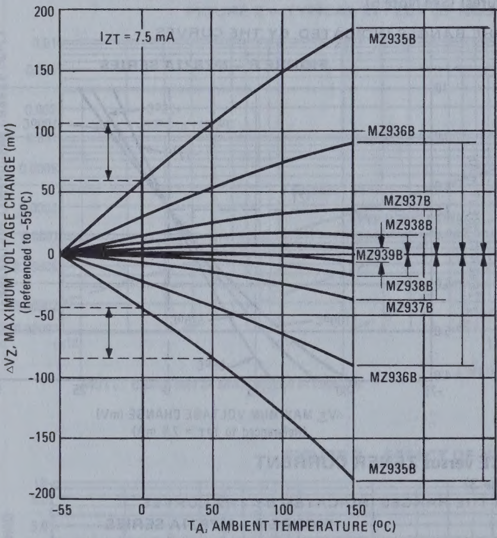


FIGURE 11 – MZ935B thru MZ939B



These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +22 mV or -22 mV for MZ935, as illustrated by the dashed lines in Figure 9. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N935,A,B thru 1N939,A,B.

The maximum voltage change, ΔV_Z, in Figure 12 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 12 to the ΔV_Z in Figure 9, 10, or 11 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 12 on Figure 9, 10, or 11.

FIGURE 12 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures) (See Note 5)

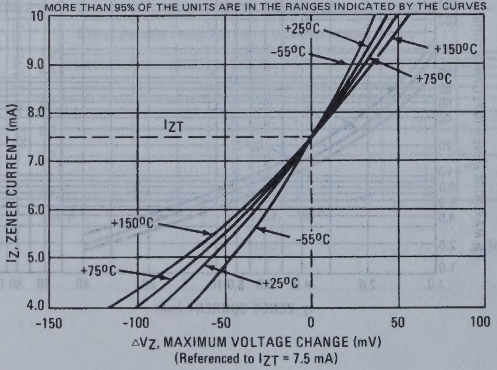
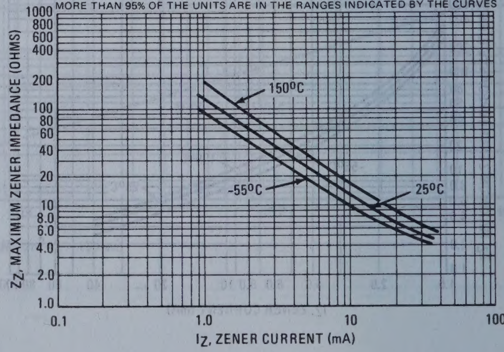


FIGURE 13 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT (See Note 3)



MZ821,A, MZ823,A, MZ825,A, MZ827,A, MZ935,A,B thru MZ938,A,B, MZ941,A,B thru MZ944,A,B, MZ3154,A thru MZ3156,A (continued)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 7.5 mA ± 0.01 mA)

FIGURE 14 — MZ941 thru MZ946

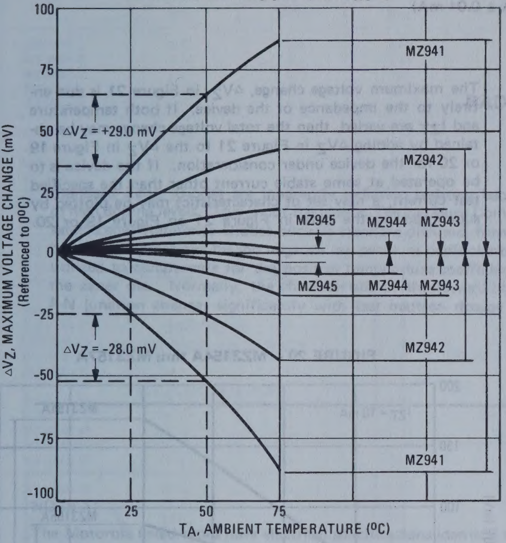


FIGURE 15 — MZ941A thru MZ946A

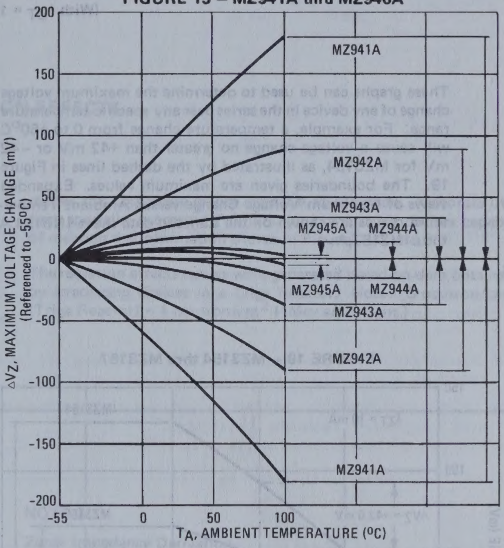
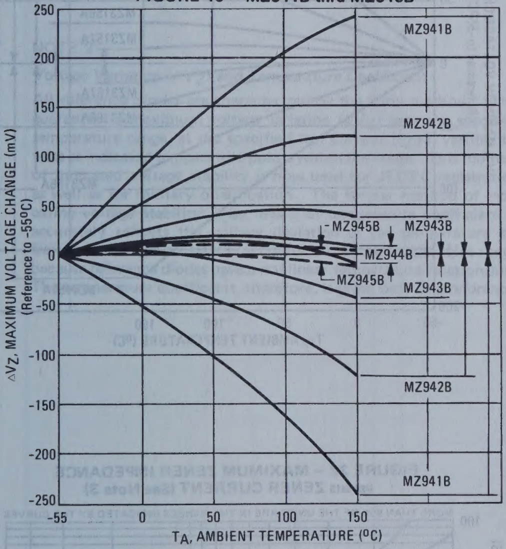


FIGURE 16 — MZ941B thru MZ946B



These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +29 mV or -28 mV for MZ941, as illustrated by the dashed lines in Figure 14. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N941,A,B thru 1N946,A,B.

The maximum voltage change, ΔV_Z, in Figure 17 is due entirely to the impedance of the device. If both temperature and I_{ZT} are vaired, then the total voltage change may be obtained by adding ΔV_Z in Figure 17 to the ΔV_Z in Figure 14, 15, or 16 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 17 on Figure 14, 15, or 16.

FIGURE 17— ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (At specified temperatures) (See Note 5)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES

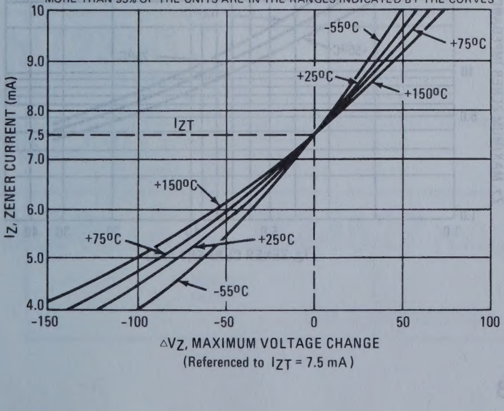
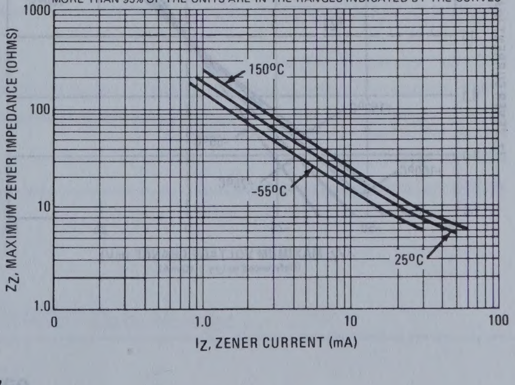


FIGURE 18 — MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT (See Note 3)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES



MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 1.0 mA ± 0.01 mA)

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +42 mV or −42 mV for MZ3154, as illustrated by the dashed lines in Figure 19. The boundaries given are maximum values. Expanded views of Maximum Voltage Change versus Ambient Temperature curves are shown on the standard data sheet 1N3154,A thru 1N3157,A.

The maximum voltage change, ΔV_Z, in Figure 21 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 21 to the ΔV_Z in Figure 19 or 20 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 21 on Figure 19 or 20.

FIGURE 19 – MZ3154 thru MZ3157

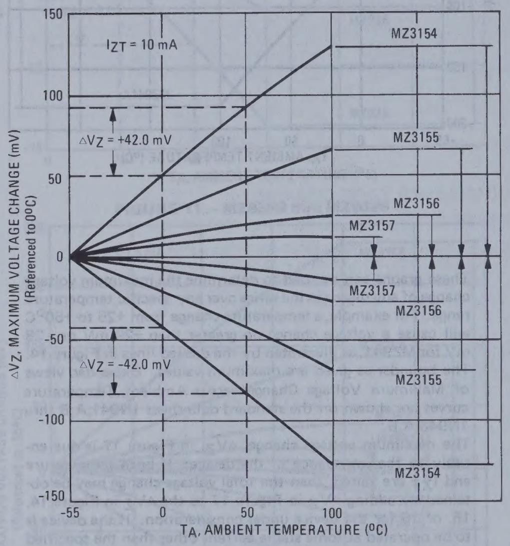


FIGURE 20 – MZ3154A thru MZ3157A

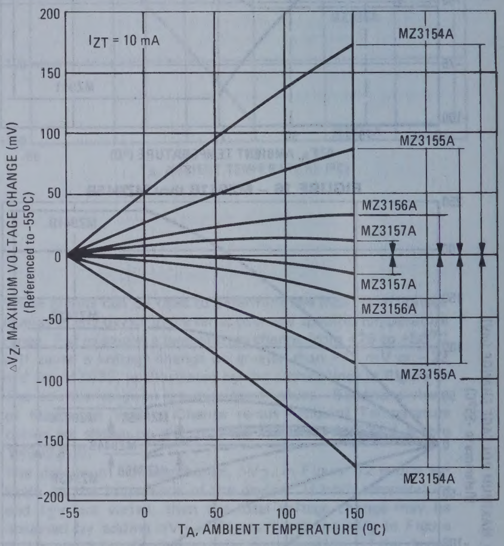


FIGURE 21 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures) (See Note 5)

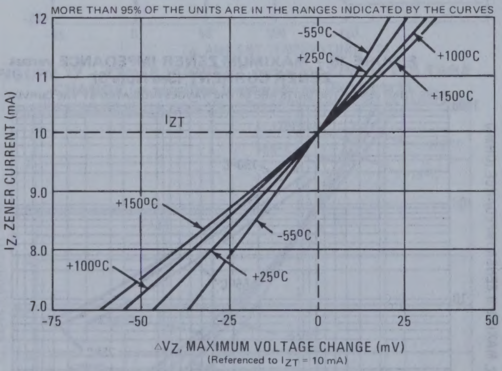
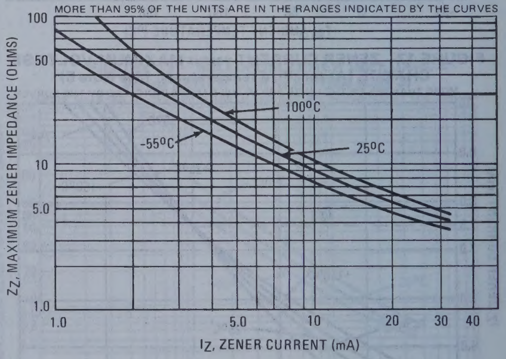


FIGURE 22 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT (See Note 3)



MZ821,A, MZ823,A, MZ825,A, MZ827,A, MZ935,A,B thru MZ938,A,B, MZ941,A,B thru MZ944,A,B, MZ3154,A thru MZ3156,A (continued)

RADIATION EFFECTS

Standard Zener Diodes are inherently radiation resistant because of high doping levels. This is not the case in Temperature Compensated Zener Reference Diodes because standard diffused, forward-biased, P-N junctions having negative temperature coefficients are utilized to compensate for the positive temperature coefficient of the zener die. Normally, the characteristic of the foward-biased P-N junction changes significantly with fast neutron dosage and makes the composite device sensitive to radiation. Motorola utilizes specially processed P-N junctions to provide devices capable of meeting the information shown in Figures 1, 2 and 3.

The radiation effects curves were generated based on data obtained by irradiating devices in a Triga Reactor. Note: 3 neutron/cm^2 (Triga Reactor) = 1 neutron/cm^2 (1Mev equivalent.)

NOTE 1:

The Motorola listed types have electrical specifications identical to the 1N . . . counterpart, i.e., MZ821 is identical to 1N821.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient

All reference diodes are characterized by the "box method." This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicated voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of the zener impedance with zener current for each series are given. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

MZ1000-1 thru MZ1000-37 (SILICON)

MINIATURE PLASTIC ENCAPSULATED ZENER DIODES

. . . for regulated power supply circuits, surge protection, arc suppression and other functions in television, automotive and other consumer product applications.

- No larger than conventional 250 mW case yet conservatively rated at 1 watt (to 3 watts dissipation possible).
- 100% oscilloscope tested to assure sharp breakdown and long-term, reliable operation.

1 WATT
ZENER DIODES

SILICON
OXIDE PASSIVATED

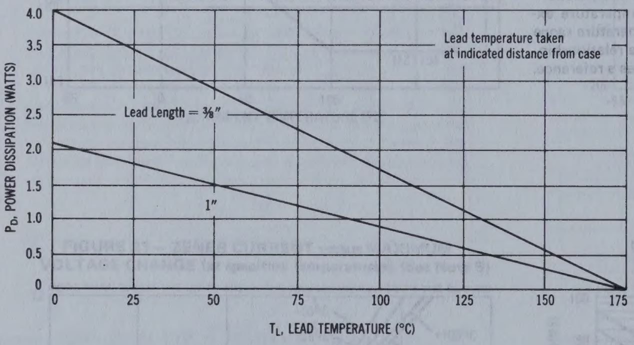
3.3-100 VOLTS

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation @ T_L = 50°C Derate above 50°C	1.5 8.33	Watts mW/°C
Lead Temperature (1)	-65 to +175	°C

(1) Maximum Lead temperature for 10 seconds at 1/16" from case = 230°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MECHANICAL CHARACTERISTICS

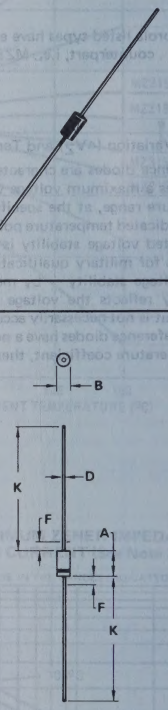
CASE: Void free, transfer molded.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.42 gram (approximately).



NOTE:
1. POLARITY DENOTED BY CATHODE BAND

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	–	1.27	–	0.050
K	27.94	–	1.100	–

All JEDEC dimensions and notes apply.

CASE 59-03
DO-41

MZ1000-1 thru MZ1000-37 (continued)

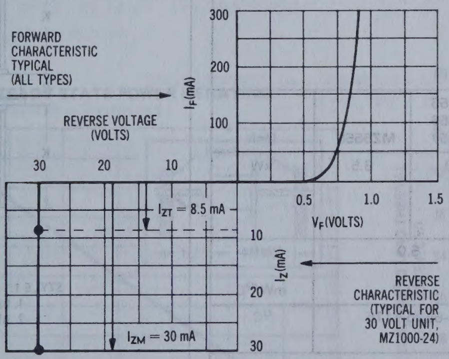
ELECTRICAL CHARACTERISTICS (T_c = 25°C unless otherwise noted) V_F = 1.5 V max @ 200 mA on all types

Motorola Type No.	Zener Voltage V_Z @ I_{ZT} Volts (2)			Test Current I_{ZT} mA	Typical Z_{ZT} @ I_{ZT} Ohms	Max DC Zener Current I_{ZM} mA	Maximum Reverse Leakage Current I_R @	V_R	Temperature Coefficient %/°C
	Min	Nom	Max				μA Max	Volts	
MZ1000-1	2.97	3.3	3.63	76	15	276	150	1	-.070
MZ1000-2	3.24	3.6	3.96	69	15	252	150	1	-.065
MZ1000-3	3.51	3.9	4.29	64	13.5	234	75	1	-.060
MZ1000-4	3.87	4.3	4.73	58	13.5	217	20	1	-.050
MZ1000-5	4.23	4.7	5.17	53	12	193	20	1	-.043
MZ1000-6	4.59	5.1	5.61	49	10.5	178	20	1	±.030
MZ1000-7	5.04	5.6	6.16	45	7.5	162	20	2	±.028
MZ1000-8	5.58	6.2	6.82	41	3	146	20	3	+.045
MZ1000-9	6.12	6.8	7.48	37	5.25	133	20	4	.050
MZ1000-10	6.75	7.5	8.25	34	6	121	20	5	.058
MZ1000-11	7.38	8.2	9.02	31	6.75	110	20	5.9	.062
MZ1000-12	8.19	9.1	10.01	28	7.5	100	20	6.6	.068
MZ1000-13	9	10	11	25	10.5	91	20	7.2	.075
MZ1000-14	9.9	11	12.1	23	12	83	10	8.0	.076
MZ1000-15	10.8	12	13.2	21	13.5	76	10	8.6	.077
MZ1000-16	11.7	13	14.3	19	15	69	10	9.4	.079
MZ1000-17	13.5	15	16.5	17	21	61	10	10.8	.082
MZ1000-18	14.4	16	17.6	15.5	24	57	10	11.5	.083
MZ1000-19	16.2	18	19.8	14	30	50	10	13.0	.085
MZ1000-20	18	20	22	12.5	33	45	10	14.4	.086
MZ1000-21	19.8	22	24.2	11.5	34.5	41	10	15.8	.087
MZ1000-22	21.6	24	26.4	10.5	37.5	38	10	17.3	.088
MZ1000-23	24.3	27	29.7	9.5	52.5	34	10	19.4	.090
MZ1000-24	27	30	33	8.5	60	30	10	21.6	.091
MZ1000-25	29.7	33	36.3	7.5	67.5	27	10	23.8	.092
MZ1000-26	32.4	36	39.6	7	75	25	10	25.9	.093
MZ1000-27	35.1	39	42.9	6.5	90	23	10	28.1	.094
MZ1000-28	38.7	43	47.3	6	105	22	10	31.0	.095
MZ1000-29	42.3	47	51.7	5.5	120	19	10	33.8	.095
MZ1000-30	45.9	51	56.1	5	142.5	18	10	36.7	.096
MZ1000-31	50.4	56	61.6	4.5	165	16	10	40.3	.096
MZ1000-32	55.8	62	68.2	4	177.5	14	10	44.6	.097
MZ1000-33	61.2	68	74.8	3.7	225	13	10	49.0	.097
MZ1000-34	67.5	75	82.5	3.3	262.5	12	10	54.0	.098
MZ1000-35	73.8	86	90.2	3	300	11	10	59.0	.098
MZ1000-36	81.9	91	100.1	2.8	375	10	10	65.5	.099
MZ1000-37	90	100	110	2.5	525	9	10	72.0	.100

(2) Nominal voltages other than those stated above, matched sets, and tighter voltage tolerances are available as listed on DS 7030 R1 (available from your local Motorola sales office or distributor) . . . Motorola 1N4728 thru 1N4764 series (1M3.3ZS10 thru 1M100ZS10).

Voltages to 200 volts are available in other package configurations on request.

FIGURE 2 — TYPICAL ZENER DIODE CHARACTERISTICS and SYMBOL IDENTIFICATION



- I_F — Forward Current
- I_Z — Zener Current
- I_{ZM} — Maximum DC Zener Current (Limited by Power Dissipation)
- I_{ZT} — Zener Test Current
- V_F — Forward Voltage
- V_Z — Nominal Zener Voltage
- Z_Z — Zener Impedance
- Z_{ZT} — Zener Impedance at Test Current (I_{ZT})

MZ2360
thru
MZ2362

For Specifications, See 1N816 Data, Volume I.

MZ4614 thru MZ4627 (SILICON)

For Specifications, See 1N4099 Data, Volume 1.

MZ5555 (SILICON)
thru
MZ5558

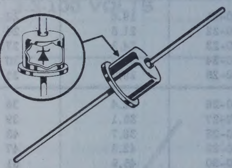
Designers Data Sheet

SILICON POWER TRANSIENT SUPPRESSORS

are highly reliable voltage regulators specifically designed to withstand high power pulses for protection of voltage transient sensitive circuits.

- Peak Power Given – 0.01 ms to 1.0 s
- Low Power Overshoot
- Low Power Loss
- Convenient Size
- Axial Lead Package
- Oxide Passivated Junction

SILICON POWER TRANSIENT SUPPRESSORS



Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves – representing boundaries on device characteristics – are given to facilitate "worst case" design.

MAXIMUM RATINGS

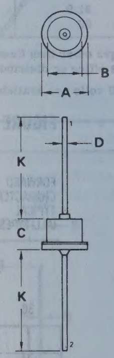
Rating	Symbol	MZ5555 MZ5556 MZ5557	MZ5558	Unit
Transient Power Dissipation Single Square Wave Pulse, Pulse Width = 0.01 ms, $T_L = 25^oC$	–	9.0	6.5	kW
DC Power Dissipation $T_L = 25^oC$, L = 0.5″ Derate above 25^oC	P_D	5.0 33.3		Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		^oC

MECHANICAL CHARACTERISTICS

CASE: Metal, hermetically sealed.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by diode symbol.



STYLE 1:
1. CATHODE
2. ANODE

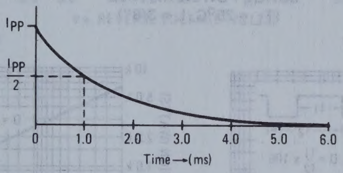
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60-02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Type Number	V_R Reverse Standoff Voltage		I_R Reverse Standoff Leakage Current @ V_R (μA)	V_Z Breakdown Voltage @ 1.0 mA (Volts)	V_C Clamping Voltage @ I_{pp} (Volts)	I_{pp} Peak Pulse Current (Note 1) (Amp)	T_C Temperature Coefficient (Note 3) (%/°C)	V_F Forward Voltage @ I_F = 100 A (Note 2) (Volts)	V_F Forward Voltage @ I_F = 200 A (Note 2) (Volts)
	(Vdc)	(VRMS)	Max	Min	Max	Max	Max	Max	Max
MZ5555	30.5	21.5	5.0	33	47.5	32	0.093	2.0	2.7
MZ5556	40.3	28.5	5.0	43.7	63.5	24	0.095	2.5	3.2
MZ5557	49	34.5	5.0	54	78.5	19	0.099	2.8	3.8
MZ5558	175	124	5.0	191	265	5.7	0.110	3.5	5.1

NOTE 1: The Peak Pulse Current is measured on an exponential curve with I_{pp} defined as follows:



NOTE 2: The Forward Current (I_F) is a non-repetitive sqaure wave pulse with a pulse width of 10 ms.

NOTE 3: Temperature Coefficient is measured at 1.0 mA over the temperature range of 25°C to 125°C.

FIGURE 1 – STEADY STATE POWER DERATING

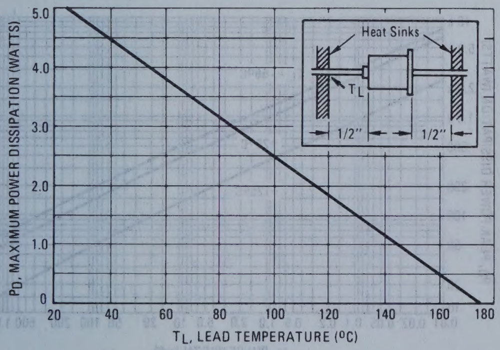


FIGURE 2 – EFFECTS OF LEAD LENGTH ON STEADY STATE THERMAL RESISTANCE

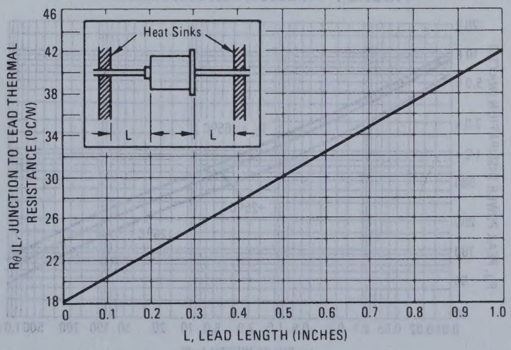


FIGURE 3 – TYPICAL VOLTAGE CHANGE WITH CURRENT

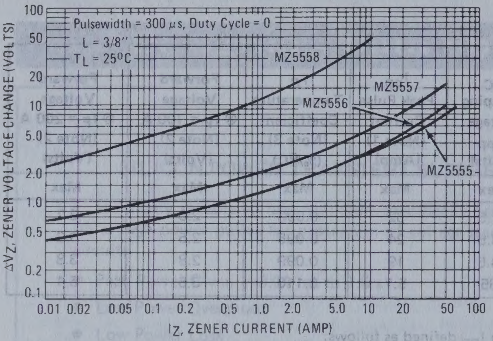
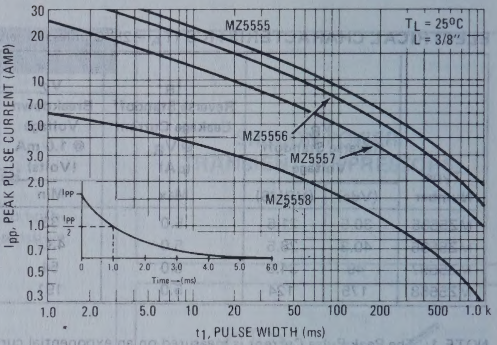


FIGURE 4 – MAXIMUM NON-REPETITIVE EXPONENTIAL SURGE CURRENT



SURGE POWER RATING
(T_L = 25°C, L = 3/8″)

FIGURE 5 – MZ5555, MZ5556, MZ5557

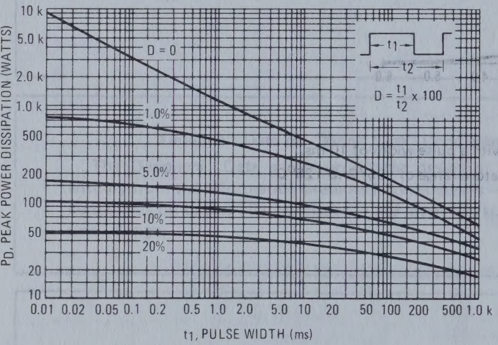
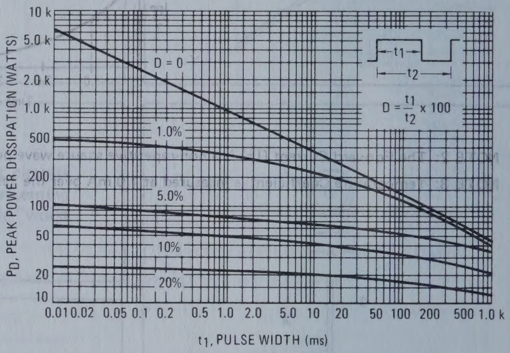


FIGURE 6 – MZ5558



NON-REPETITIVE SURGE POWER versus TEMPERATURE
(L = 3/8″, D = 0)

FIGURE 7 – MZ5555, MZ5556, MZ5557

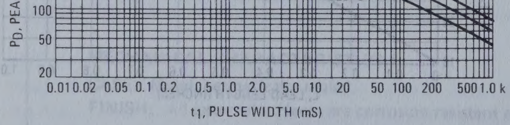


FIGURE 8 – MZ5558

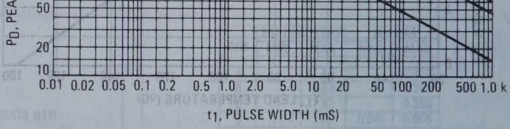
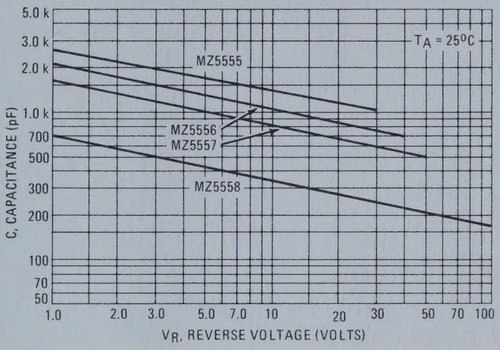


FIGURE 9 – TYPICAL CAPACITANCE



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